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WO 02/074751 A1

(54) Title: METALLOPROTEINASE INHIBITORS

(57) Abstract: Compounds of the formula (I) wherein Z is $SO_2(N6)$ or $N(R7)SO_2$ or $N(R7)SO_2N(R6)$ useful as metalloproteinase inhibitors, especially as inhibitors of MMP12.

Metalloproteinase inhibitors

The present invention relates to compounds useful in the inhibition of metalloproteinases and in particular to pharmaceutical compositions comprising these, as well as their use.

The compounds of this invention are inhibitors of one or more metalloproteinase enzymes. Metalloproteinases are a superfamily of proteinases (enzymes) whose numbers in recent years have increased dramatically. Based on structural and functional considerations these enzymes have been classified into families and subfamilies as described in N.M. Hooper (1994) FEBS Letters 354:1-6. Examples of metalloproteinases include the matrix metalloproteinases (MMPs) such as the collagenases (MMP1, MMP8, MMP13), the gelatinases (MMP2, MMP9), the stromelysins (MMP3, MMP10, MMP11), matrilysin (MMP7), metalloelastase (MMP12), enamelysin (MMP19), the MT-MMPs (MMP14, MMP15, MMP16, MMP17); the reprolysin or adamalysin or MDC family which includes the secretases and sheddases such as TNF converting enzymes (ADAM10 and TACE); the astacin family which include enzymes such as procollagen processing proteinase (PCP); and other metalloproteinases such as aggrecanase, the endothelin converting enzyme family and the angiotensin converting enzyme family.

Metalloproteinases are believed to be important in a plethora of physiological disease processes that involve tissue remodelling such as embryonic development, bone formation and uterine remodelling during menstruation. This is based on the ability of the metalloproteinases to cleave a broad range of matrix substrates such as collagen, proteoglycan and fibronectin. Metalloproteinases are also believed to be important in the processing, or secretion, of biological important cell mediators, such as tumour necrosis factor (TNF); and the post translational proteolysis processing, or shedding, of biologically important membrane proteins, such as the low affinity IgE receptor CD23 (for a more complete list see N. M. Hooper *et al.*, (1997) Biochem J. 321:265-279).

Metalloproteinases have been associated with many diseases or conditions. Inhibition of the activity of one or more metalloproteinases may well be of benefit in these diseases

or conditions, for example: various inflammatory and allergic diseases such as, inflammation of the joint (especially rheumatoid arthritis, osteoarthritis and gout), inflammation of the gastro-intestinal tract (especially inflammatory bowel disease, ulcerative colitis and gastritis), inflammation of the skin (especially psoriasis, eczema, dermatitis); in tumour metastasis or invasion; in disease associated with uncontrolled degradation of the extracellular matrix such as osteoarthritis; in bone resorptive disease (such as osteoporosis and Paget's disease); in diseases associated with aberrant angiogenesis; the enhanced collagen remodelling associated with diabetes, periodontal disease (such as gingivitis), corneal ulceration, ulceration of the skin, post-operative conditions (such as colonic anastomosis) and dermal wound healing; demyelinating diseases of the central and peripheral nervous systems (such as multiple sclerosis); Alzheimer's disease; extracellular matrix remodelling observed in cardiovascular diseases such as restenosis and atheroscelerosis; asthma; rhinitis; and chronic obstructive pulmonary diseases (COPD).

MMP12, also known as macrophage elastase or metalloelastase, was initially cloned in the mouse by Shapiro *et al* [1992, Journal of Biological Chemistry 267: 4664] and in man by the same group in 1995. MMP-12 is preferentially expressed in activated macrophages, and has been shown to be secreted from alveolar macrophages from smokers [Shapiro *et al*, 1993, Journal of Biological Chemistry, 268: 23824] as well as in foam cells in atherosclerotic lesions [Matsumoto *et al*, 1998, Am J Pathol 153: 109]. A mouse model of COPD is based on challenge of mice with cigarette smoke for six months, two cigarettes a day six days a week. Wildtype mice developed pulmonary emphysema after this treatment. When MMP12 knock-out mice were tested in this model they developed no significant emphysema, strongly indicating that MMP-12 is a key enzyme in the COPD pathogenesis. The role of MMPs such as MMP12 in COPD (emphysema and bronchitis) is discussed in Anderson and Shinagawa, 1999, Current Opinion in Anti-inflammatory and Immunomodulatory Investigational Drugs 1(1): 29-38. It was recently discovered that smoking increases macrophage infiltration and macrophage-derived MMP-12 expression

in human carotid artery plaques Kangavari [Matetzky S, Fishbein MC *et al.*, Circulation 102:(18), 36-39 Suppl. S, Oct 31, 2000].

MMP13, or collagenase 3, was initially cloned from a cDNA library derived from a breast tumour [J. M. P. Freije *et al.* (1994) Journal of Biological Chemistry 269(24):16766-16773]. PCR-RNA analysis of RNAs from a wide range of tissues indicated that MMP13 expression was limited to breast carcinomas as it was not found in breast fibroadenomas, normal or resting mammary gland, placenta, liver, ovary, uterus, prostate or parotid gland or in breast cancer cell lines (T47-D, MCF-7 and ZR75-1). Subsequent to this observation MMP13 has been detected in transformed epidermal keratinocytes [N. Johansson *et al.*, (1997) Cell Growth Differ. 8(2):243-250], squamous cell carcinomas [N. Johansson *et al.*, (1997) Am. J. Pathol. 151(2):499-508] and epidermal tumours [K. Airola *et al.*, (1997) J. Invest. Dermatol. 109(2):225-231]. These results are suggestive that MMP13 is secreted by transformed epithelial cells and may be involved in the extracellular matrix degradation and cell-matrix interaction associated with metastasis especially as observed in invasive breast cancer lesions and in malignant epithelia growth in skin carcinogenesis.

Recent published data implies that MMP13 plays a role in the turnover of other connective tissues. For instance, consistent with MMP13's substrate specificity and preference for degrading type II collagen [P. G. Mitchell *et al.*, (1996) J. Clin. Invest. 97(3):761-768; V. Knauper *et al.*, (1996) The Biochemical Journal 271:1544-1550], MMP13 has been hypothesised to serve a role during primary ossification and skeletal remodelling [M. Stahle-Backdahl *et al.*, (1997) Lab. Invest. 76(5):717-728; N. Johansson *et al.*, (1997) Dev. Dyn. 208(3):387-397], in destructive joint diseases such as rheumatoid and osteo-arthritis [D. Wernicke *et al.*, (1996) J. Rheumatol. 23:590-595; P. G. Mitchell *et al.*, (1996) J. Clin. Invest. 97(3):761-768; O. Lindy *et al.*, (1997) Arthritis Rheum 40(8):1391-1399]; and during the aseptic loosening of hip replacements [S. Imai *et al.*, (1998) J. Bone Joint Surg. Br. 80(4):701-710]. MMP13 has also been implicated in chronic adult periodontitis as it has been localised to the epithelium of chronically inflamed mucosa human gingival tissue [V. J. Uitto *et al.*, (1998) Am. J. Pathol

152(6):1489-1499] and in remodelling of the collagenous matrix in chronic wounds [M. Vaalamo *et al.*, (1997) J. Invest. Dermatol. 109(1):96-101].

MMP9 (Gelatinase B; 92kDa TypeIV Collagenase; 92kDa Gelatinase) is a secreted protein which was first purified, then cloned and sequenced, in 1989 [S.M. Wilhelm *et al* (1989) J. Biol Chem. 264 (29): 17213-17221; published erratum in J. Biol Chem. (1990) 265 (36): 22570]. A recent review of MMP9 provides an excellent source for detailed information and references on this protease: T.H. Vu & Z. Werb (1998) (In : Matrix Metalloproteinases. 1998. Edited by W.C. Parks & R.P. Mecham. pp115 - 148. Academic Press. ISBN 0-12-545090-7). The following points are drawn from that review by T.H. Vu & Z. Werb (1998).

The expression of MMP9 is restricted normally to a few cell types, including trophoblasts, osteoclasts, neutrophils and macrophages. However, it's expression can be induced in these same cells and in other cell types by several mediators, including exposure of the cells to growth factors or cytokines. These are the same mediators often implicated in initiating an inflammatory response. As with other secreted MMPs, MMP9 is released as an inactive Pro-enzyme which is subsequently cleaved to form the enzymatically active enzyme. The proteases required for this activation *in vivo* are not known. The balance of active MMP9 versus inactive enzyme is further regulated *in vivo* by interaction with TIMP-1 (Tissue Inhibitor of Metalloproteinases -1), a naturally-occurring protein. TIMP-1 binds to the C-terminal region of MMP9, leading to inhibition of the catalytic domain of MMP9. The balance of induced expression of ProMMP9, cleavage of Pro- to active MMP9 and the presence of TIMP-1 combine to determine the amount of catalytically active MMP9 which is present at a local site. Proteolytically active MMP9 attacks substrates which include gelatin, elastin, and native Type IV and Type V collagens; it has no activity against native Type I collagen, proteoglycans or laminins.

There has been a growing body of data implicating roles for MMP9 in various physiological and pathological processes. Physiological roles include the invasion of embryonic trophoblasts through the uterine epithelium in the early stages of embryonic

implantation; some role in the growth and development of bones; and migration of inflammatory cells from the vasculature into tissues.

MMP-9 release, measured using enzyme immunoassay, was significantly enhanced in fluids and in AM supernantants from untreated asthmatics compared with those from other populations [Am. J. Resp. Cell & Mol. Biol., Nov 1997, 17 (5):583-591]. Also, increased MMP9 expression has been observed in certain other pathological conditions, thereby implicating MMP9 in disease processes such as COPD, arthritis, tumour metastasis, Alzheimer's, Multiple Sclerosis, and plaque rupture in atherosclerosis leading to acute coronary conditions such as Myocardial Infarction.

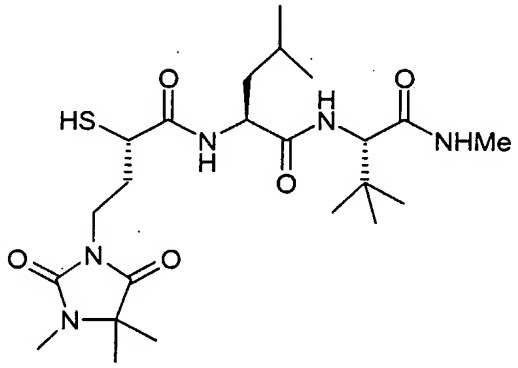
MMP-8 (collagenase-2, neutrophil collagenase) is a 53 kD enzyme of the matrix metalloproteinase family that is preferentially expressed in neutrophils. Later studies indicate MMP-8 is expressed also in other cells, such as osteoarthritic chondrocytes [Shlopov *et al*, 1997, Arthritis Rheum, 40:2065]. MMPs produced by neutrophils can cause tissue remodelling, and hence blocking MMP-8 should have a positive effect in fibrotic diseases of for instance the lung, and in degradative diseases like pulmonary emphysema. MMP-8 was also found to be up-regulated in osteoarthritis, indicating that blocking MMP-8 many also be beneficial in this disease.

MMP-3 (stromelysin-1) is a 53 kD enzyme of the matrix metalloproteinase enzyme family. MMP-3 activity has been demonstrated in fibroblasts isolated from inflamed gingiva [Uitto V. J. *et al*, 1981, J. Periodontal Res., 16:417-424], and enzyme levels have been correlated to the severity of gum disease [Overall C. M. *et al*, 1987, J. Periodontal Res., 22:81-88]. MMP-3 is also produced by basal keratinocytes in a variety of chronic ulcers [Saarialho-Kere U. K. *et al*, 1994, J. Clin. Invest., 94:79-88]. MMP-3 mRNA and protein were detected in basal keratinocytes adjacent to but distal from the wound edge in what probably represents the sites of proliferating epidermis. MMP-3 may thus prevent the epidermis from healing. Several investigators have demonstrated consistent elevation of MMP-3 in synovial fluids from rheumatoid and osteoarthritis patients as compared to controls [Walakovits L. A. *et al*, 1992, Arthritis Rheum., 35:35-42; Zafarullah M. *et al*, 1993, J. Rheumatol., 20:693-697]. These studies provided the basis for the belief that an

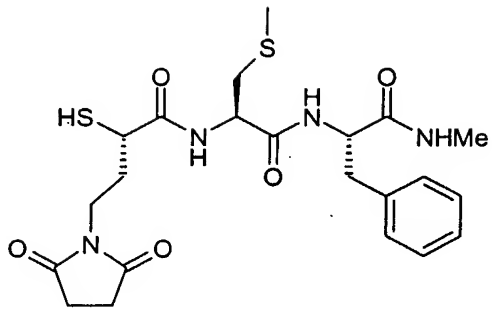
inhibitor of MMP-3 will treat diseases involving disruption of extracellular matrix resulting in inflammation due to lymphocytic infiltration, or loss of structural integrity necessary for organ function.

A number of metalloproteinase inhibitors are known (see for example the review of MMP inhibitors by Beckett R.P. and Whittaker M., 1998, Exp. Opin. Ther. Patents, 8(3):259-282]. Different classes of compounds may have different degrees of potency and selectivity for inhibiting various metalloproteinases.

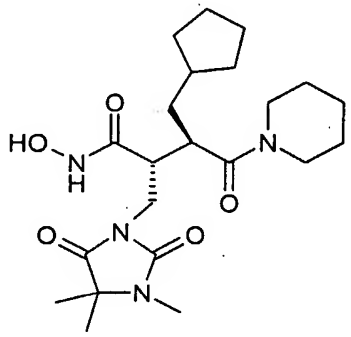
Whittaker M. *et al* (1999, Chemical Reviews 99(9):2735-2776] review a wide range of known MMP inhibitor compounds. They state that an effective MMP inhibitor requires a zinc binding group or ZBG (functional group capable of chelating the active site zinc(II) ion), at least one functional group which provides a hydrogen bond interaction with the enzyme backbone, and one or more side chains which undergo effective van der Waals interactions with the enzyme subsites. Zinc binding groups in known MMP inhibitors include carboxylic acid groups, hydroxamic acid groups, sulfhydryl or mercapto, etc. For example, Whittaker M. *et al* discuss the following MMP inhibitors:



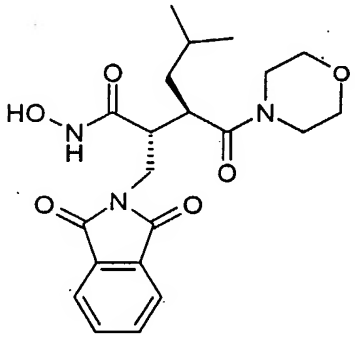
The above compound entered clinical development. It has a mercaptoacyl zinc binding group, a trimethylhydantoinylethyl group at the P1 position and a leucinyl-*tert*-butyllglycinyl backbone.



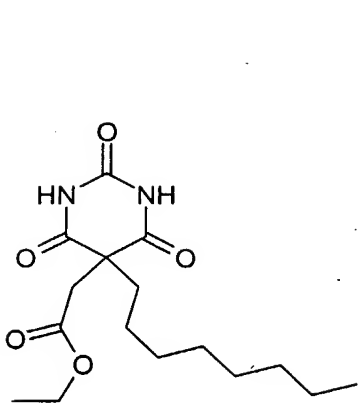
The above compound has a mercaptoacyl zinc binding group and an imide group at the P1 position.

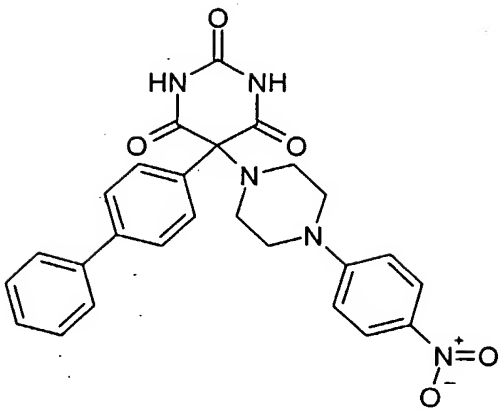


The above compound was developed for the treatment of arthritis. It has a non-peptidic succinyl hydroxamate zinc binding group and a trimethylhydantoinylethyl group at the P1 position.



The above compound is a phthalimido derivative that inhibits collagenases. It has a non-peptidic succinyl hydroxamate zinc binding group and a cyclic imide group at P1. Whittaker M. *et al* also discuss other MMP inhibitors having a P1 cyclic imido group and various zinc binding groups (succinyl hydroxamate, carboxylic acid, thiol group, phosphorous-based group).

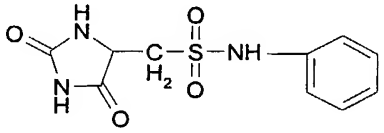


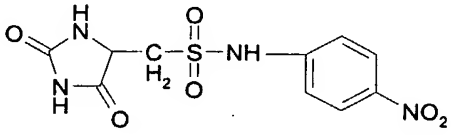


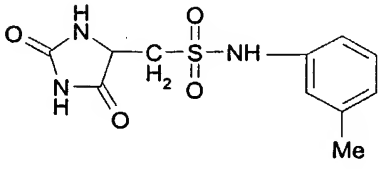
The above compounds appear to be good inhibitors of MMP8 and MMP9 (PCT patent applications WO9858925, WO9858915). They have a pyrimidin-2,3,4-trione zinc binding group.

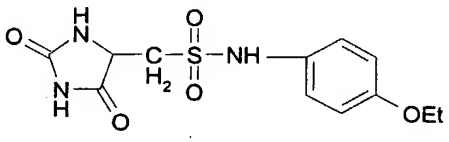
The following compounds are not known as MMP inhibitors:-

Lora-Tamayo, M *et al* (1968, An. Quim 64(6): 591-606) describe synthesis of the following compounds as a potential anti-cancer agent:

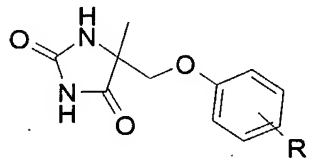


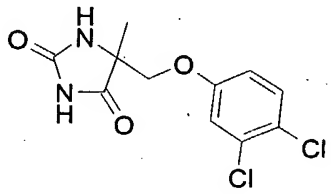






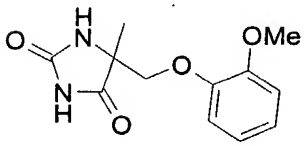
Czech patent numbers 151744 (19731119) and 152617 (1974022) describe the synthesis and the anticonvulsive activity of the following compounds:

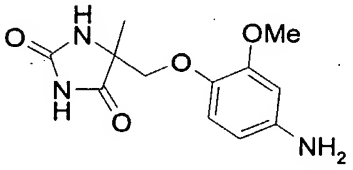


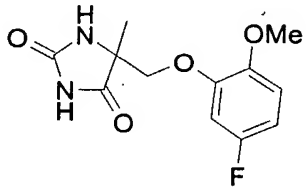


R= 4-NO2, 4-OMe, 2-NO2,

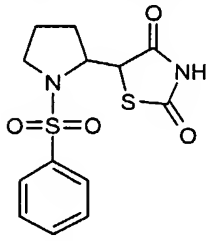
US patent number 3529019 (19700915) describes the following compounds used as intermediates:

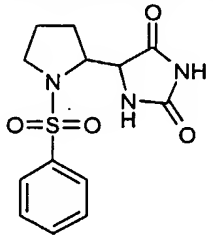






PCT patent application number WO 00/09103 describes compounds useful for treating a vision disorder, including the following (compounds 81 and 83, Table A, page 47):

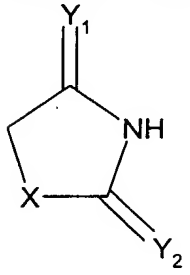




We have now discovered a new class of compounds that are inhibitors of metalloproteinases and are of particular interest in inhibiting MMPs such as MMP-12. The compounds are metalloproteinase inhibitors having a metal binding group that is not found in known metalloproteinase inhibitors. In particular, we have discovered compounds that

are potent MMP12 inhibitors and have desirable activity profiles. The compounds of this invention have beneficial potency, selectivity and/or pharmacokinetic properties.

The metalloproteinase inhibitor compounds of the invention comprise a metal binding group and one or more other functional groups or side chains characterised in that the metal binding group has the formula (k)



(k)

wherein **X** is selected from NR1, O, S;

Y1 and **Y2** are independently selected from O, S;

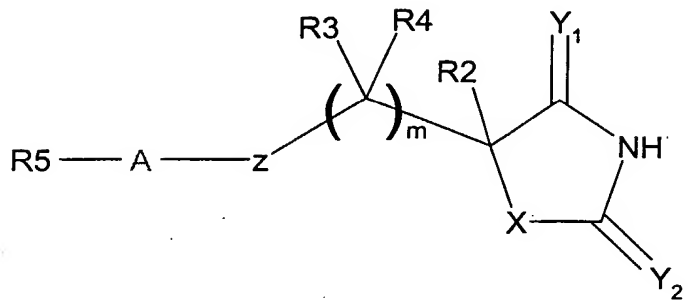
R1 is selected from H, alkyl, haloalkyl;

Any alkyl groups outlined above may be straight chain or branched; any alkyl group outlined above is preferably (C1-7)alkyl and most preferably (C1-6)alkyl.

A metalloproteinase inhibitor compound is a compound that inhibits the activity of a metalloproteinase enzyme (for example, an MMP). By way of non-limiting example the inhibitor compound may show IC50s *in vitro* in the range of 0.1-10000 nanomolar, preferably 0.1-1000 nanomolar.

A metal binding group is a functional group capable of binding the metal ion within the active site of the enzyme. For example, the metal binding group will be a zinc binding group in MMP inhibitors, binding the active site zinc(II) ion. The metal binding group of formula (k) is based on a five-membered ring structure and is preferably a hydantoin group, most preferably a -5 substituted 1-H,3-H-imidazolidine-2,4-dione.

In a first aspect of the invention we now provide compounds of the formula I



I

wherein

X is selected from NR1, O, S;

Y1 and **Y2** are independently selected from O, S;

Z is selected from $SO_2N(R6)$, $N(R7)SO_2$, $N(R7)SO_2N(R6)$;

m is 1 or 2;

A is selected from a direct bond, (C1-6)alkyl, (C1-6)haloalkyl, or (C1-6)heteroalkyl containing a hetero group selected from N, O, S, SO, SO2 or containing two hetero groups selected from N, O, S, SO, SO2 and separated by at least two carbon atoms;

R1 is selected from H, (C1-3)alkyl, haloalkyl;

Each **R2** and **R3** is independently selected from H, halogen (preferably fluorine), alkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, alkylaryl, alkyl-heteroaryl, heteroalkyl-aryl, heteroalkyl-heteroaryl, aryl-alkyl, aryl-heteroalkyl, heteroaryl-alkyl, heteroaryl-heteroalkyl, aryl-aryl, aryl-heteroaryl, heteroaryl-aryl, heteroaryl-heteroaryl, cycloalkyl-alkyl, heterocycloalkyl-alkyl;

Each **R4** is independently selected from H, halogen (preferably fluorine), (C1-3)alkyl or haloalkyl;

R6 is selected from H, alkyl, heteroalkyl, heterocycloalkyl, aryl, heteroaryl, alkylaryl, alkyl-heteroaryl, heteroalkyl-aryl, heteroalkyl-heteroaryl, arylalkyl, aryl-heteroalkyl, heteroaryl-alkyl, heteroaryl-heteroalkyl, aryl-aryl, aryl-heteroaryl, heteroaryl-aryl, heteroaryl-heteroaryl;

Each of the **R2**, **R3** and **R6** radicals may be independently optionally substituted with one or more (preferably one) groups selected from alkyl, heteroalkyl, aryl, heteroaryl, halo, haloalkyl, hydroxy, alkoxy, haloalkoxy, thiol, alkylthiol, arylthiol, alkylsulfon, haloalkylsulfon, arylsulfon, aminosulfon, N-alkylaminosulfon, N,N-dialkylaminosulfon, arylaminosulfon, amino, N-alkylamino, N,N-dialkylamino, amido, N-alkylamido, N,N-dialkylamido, cyano, sulfonamino, alkylsulfonamino, arylsulfonamino, amidino, N-aminosulfon-amidino, guanidino, N-cyano-guanidino, thioguanidino, 2-nitro-ethene-1,1-diamin, carboxy, alkyl-carboxy, nitro;

Optionally **R2** and **R3** may join to form a ring comprising up to 7 ring atoms, or **R2** and **R4** may join to form a ring comprising up to 7 ring atoms, or **R2** and **R6** may join to form a ring comprising up to 7 ring atoms, or **R3** and **R4** may join to form a ring comprising up to 7 ring atoms, or **R3** and **R6** may join to form a ring comprising up to 7 ring atoms, or **R4** and **R6** may join to form a ring comprising up to 7 ring atoms;

R5 is a monocyclic, bicyclic or tricyclic group comprising one, two or three ring structures each of up to 7 ring atoms independently selected from cycloalkyl, aryl, heterocycloalkyl or heteroaryl, with each ring structure being independently optionally substituted by one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, haloalkoxy, amino, N-alkylamino, N,N-dialkylamino, alkylsulfonamino, alkylcarboxyamino, cyano, nitro, thiol, alkylthiol, alkylsulfonyl, haloalkylsulfonyl, alkylaminosulfonyl, carboxylate, alkylcarboxylate, aminocarboxy, N-alkylamino-carboxy, N,N-dialkylamino-carboxy, wherein any alkyl radical within any substituent may itself be optionally substituted with one or more groups selected from halogen, hydroxy, alkoxy, haloalkoxy, amino, N-alkylamino, N,N-dialkylamino, N-alkylsulfonamino, N-alkylcarboxyamino, cyano, nitro, thiol, alkylthiol, alkylsulfonyl, N-alkylaminosulfonyl, carboxylate, alkylcarboxy, aminocarboxy, N-alkylaminocarboxy, N,N-dialkylaminocarboxy;

when **R5** is a bicyclic or tricyclic group, each ring structure is joined to the next ring structure by a direct bond, by -O-, by (C1-6)alkyl, by (C1-6)haloalkyl,

by (C1-6)heteroalkyl, by (C1-6)alkenyl, by (C1-6)alkynyl, by sulfone, or is fused to the next ring structure;

R7 is selected from (C1-6) alkyl, (C3-7)cycloalkyl, (C2-6)heteroalkyl, (C2-6)cycloheteroalkyl;

Any heteroalkyl group outlined above is a hetero atom-substituted alkyl containing one or more hetero groups independently selected from N, O, S, SO, SO2, (a hetero group being a hetero atom or group of atoms);

Any heterocycloalkyl or heteroaryl group outlined above contains one or more hetero groups independently selected from N, O, S, SO, SO2;

Any alkyl, alkenyl or alkynyl groups outlined above may be straight chain or branched; unless otherwise stated, any alkyl group outlined above is preferably (C1-7)alkyl and most preferably (C1-6)alkyl;

Provided that:

when X is NR1, R1 is H, Y1 is O, Y2 is O, Z is $SO_2N(R6)$, R6 is H, R2 is H, m is 1, R3 is H, R4 is H, and A is a direct bond, then R5 is not phenyl, p-nitro-phenyl, p-ethoxyphenyl or m-methylphenyl;

when X is S or NR1 and R1 is H, Y1 is O, Y2 is O, Z is $SO_2N(R6)$, R6 is alkyl, R2 is H, m is 1, one of R3 and R4 is H and the other is alkyl, R3 and R6 or R4 and R6 join to form a 5-membered ring, and A is a direct bond, then R5 is not phenyl.

Preferred compounds of the formula I are those wherein any one or more of the following apply:

X is NR1;

Z is $SO_2N(R6)$, especially wherein the S atom of group Z is attached to group A in the compound of formula I;

At least one of Y1 and Y2 is O; especially both Y1 and Y2 are O;

m is 1;

R1 is H, (C1-3) alkyl, (C1-3) haloalkyl; especially R1 is H;

R2 is H, alkyl, hydroxyalkyl, aminoalkyl, cycloalkyl-alkyl, alkyl-cycloalkyl, arylalkyl, alkylaryl, heteroalkyl, heterocycloalkyl-alkyl, alkyl-heterocycloalkyl, heteroaryl-alkyl, heteroalkyl-aryl; especially R2 is alkyl, aminoalkyl or heteroaryl-alkyl.

R3 and/or R4 is H;

R3 and/or R4 is methyl;

R3 and R4 form a 5- or 6-membered ring (preferably a 5-membered ring) or R3 and R6 form a 5- or 6-membered ring (preferably a 5-membered ring) or R4 and R6 form a 5- or 6-membered ring (preferably a 5-membered ring); especially R3 and R6 form a 5- or 6-membered ring, most preferably a 5-membered ring;

R2 and R3 form a 5-membered ring or R2 and R6 form a 5-membered ring;

R5 comprises one, two or three optionally substituted aryl or heteroaryl 5- or 6-membered rings;

R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures;

R3 and R6 form a 5- or 6-membered ring (preferably a 5-membered ring) or R4 and R6 form a 5- or 6-membered ring (preferably a 5-membered ring) and R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures.

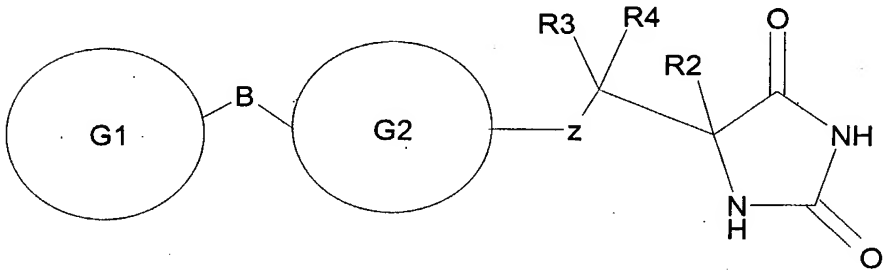
Particularly preferred compounds of formula I are those wherein R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures.

For example, particular compounds of formula I are those wherein Y1 is O, Y2 is O, X is NR1, R1 is H, R2 is H, m is 1, R3 is H, R4 is H, Z is $SO_2N(R6)$, R6 is H, (C1-4)alkyl, methylbenzyl, or methylpyridyl, A is a direct bond, and R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures. Some such compounds are described in Examples 1 and 2.

Other particular compounds of formula I are those wherein Y1 is O, Y2 is O, X is NR1, R1 is H, R2 is H, methyl, or benzyl, m is 1, R3 is H or methyl, R4 is H, Z is

$SO_2N(R6)$, R6 is H, A is a direct bond, and R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures. Some such compounds are described in Example 3.

The invention further provides compounds of the formula II



II

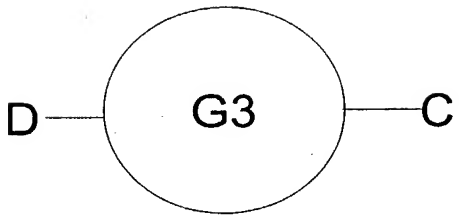
wherein

each of **G1** and **G2** is a monocyclic ring structure comprising each of up to 7 ring atoms independently selected from cycloalkyl, aryl, heterocycloalkyl or heteroaryl, with each ring structure being independently optionally substituted by one or two substituents independently selected from halogen, hydroxy, haloalkoxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkyl, alkoxy, alkyl sulfone, haloalkyl sulfone, alkylcarbamate, alkylamide, wherein any alkyl radical within any substituent may itself be optionally substituted with one or more groups selected from halogen, hydroxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkoxy, haloalkoxy;

Z is $SO_2N(R6)$;

B is selected from a direct bond, O, (C1-6)alkyl, (C1-6)heteroalkyl;

R2 is selected from H, (C1-6)alkyl, haloalkyl, hydroxyalkyl, alkoxyalkyl, aminoalkyl, (N-alkylamino)alkyl, (N,N-dialkylamino)alkyl, amidoalkyl, thioalkyl, or R2 is a group of formula III



Formula III

C and **D** are independently selected from a direct bond, H, (C1-C6)alkyl, (C1-C6)haloalkyl, or (C1-C6)heteroalkyl containing one or two hetero atoms selected from N, O or S such that when two hetero atoms are present they are separated by at least two carbon atoms;

G3 is a monocyclic ring structure comprising up to 7 ring atoms independently selected from cycloalkyl, aryl, heterocycloalkyl or heteroaryl, optionally substituted by one or two substituents independently selected from halogen, hydroxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkyl, alkoxy, alkyl sulfone, haloalkyl sulfone, or alkyl substituted with one or more groups selected from halogen, hydroxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkoxy, haloalkoxy;

Optionally **R2** is substituted with halo, haloalkyl, hydroxy, alkoxy, haloalkoxy, amino, aminoalkyl, N-alkylamino, N,N-dialkylamino, (N-alkylamino)alkyl, (N,N-dialkylamino)alkyl, alkylsulfone, aminosulfone, N-alkylamino-sulfone, N,N-dialkylamino-sulfone, amido, N-alkylamido, N,N-dialkylamido, cyano, sulfonamino, alkyl-sulfonamino, amidino, N-aminosulfone-amidino, guanidino, N-cyano-guanidino, thioguanidino, 2-nitroguanidino, 2-nitro-ethene-1,1-diamino, carboxy, alkylcarboxy;

R3 and **R4** are independentyl selected from H or (C1-3)alkyl;

R6 is selected from H, (C1-3)alkylamino, or R6 is (C1-3)alkyl optionally substituted by aryl, heteroaryl, heterocycloalkyl;

Optionally **R2** and **R3** may join to form a ring comprising up to 7 ring atoms, or **R2** and **R4** may join to form a ring comprising up to 7 ring atoms, or **R2** and **R6** may join to form a ring comprising up to 7 ring atoms, or **R3** and **R4** may join to form a ring

comprising up to 7 ring atoms, or **R3** and **R6** may join to form a ring comprising up to 7 ring atoms, or **R4** and **R6** may join to form a ring comprising up to 7 ring atoms;

Any heteroalkyl group outlined above is a hetero atom-substituted alkyl containing one or more hetero groups independently selected from N, O, S, SO, SO2, (a hetero group being a hetero atom or group of atoms);

Any heterocycloalkyl or heteroaryl group outlined above contains one or more hetero groups independently selected from N, O, S, SO, SO2;

Any alkyl, alkenyl or alkynyl groups outlined above may be straight chain or branched; unless otherwise stated, any alkyl group outlined above is preferably (C1-7)alkyl and most preferably (C1-6)alkyl.

Preferred compounds of the formula II are those wherein one or more of the following apply:

Z is $SO_2N(R6)$ and the S atom of group Z is attached to the G2 ring;

B is a direct bond or O;

R2 is not optionally substituted, or R2 is selected from H, (C1-6)alkyl, aryl-(C1-6)alkyl or heteroaryl-(C1-6)alkyl optionally substituted with halo, haloalkyl, hydroxy, alkoxy, haloalkoxy, amino, aminoalkyl, N-alkylamino, N,N-dialkylamino, (N-alkylamino)alkyl, (N,N-dialkylamino)alkyl, alkylsulfone, aminosulfone, N-alkylamino-sulfone, N,N-dialkylamino-sulfone, amido, N-alkylamido, N,N-dialkylamido, cyano, sulfonamino, alkyl-sulfonamino, amidino, N-aminosulfone-amidino, guanidino, N-cyano-guanidino, thioguanidino, 2-nitroguanidino, 2-nitro-ethene-1,1-diamino, caboxy, alkylcarboxy;

Each of R3 and R4 is H;

R6 is H, benzyl or methylenepyridine;

G1 and G2 are each selected from an aryl or a heteroaryl;

R3 and R4 form a 5- or 6-membered ring (preferably a 5-membered ring) or R3 and R6 form a 5- or 6-membered ring (preferably a 5-membered ring) or R4 and R6 form a 5-

or 6-membered ring (preferably a 5-membered ring); especially R3 and R6 form a 5- or 6-membered ring, most preferably a 5-membered ring;

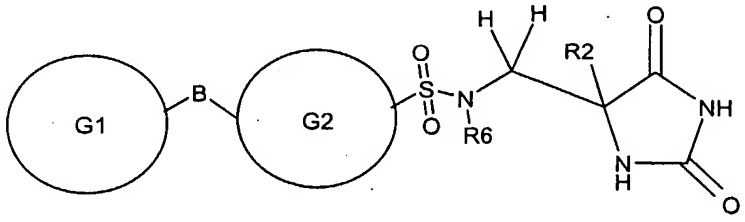
R2 and R3 form a 5-membered ring or R2 and R6 form a 5-membered ring.

Particularly preferred compounds of the formula II are those wherein Z is $SO_2N(R6)$ and the S atom of group Z is attached to the G2 ring.

For example, particular compounds of the invention include compounds of formula II wherein:

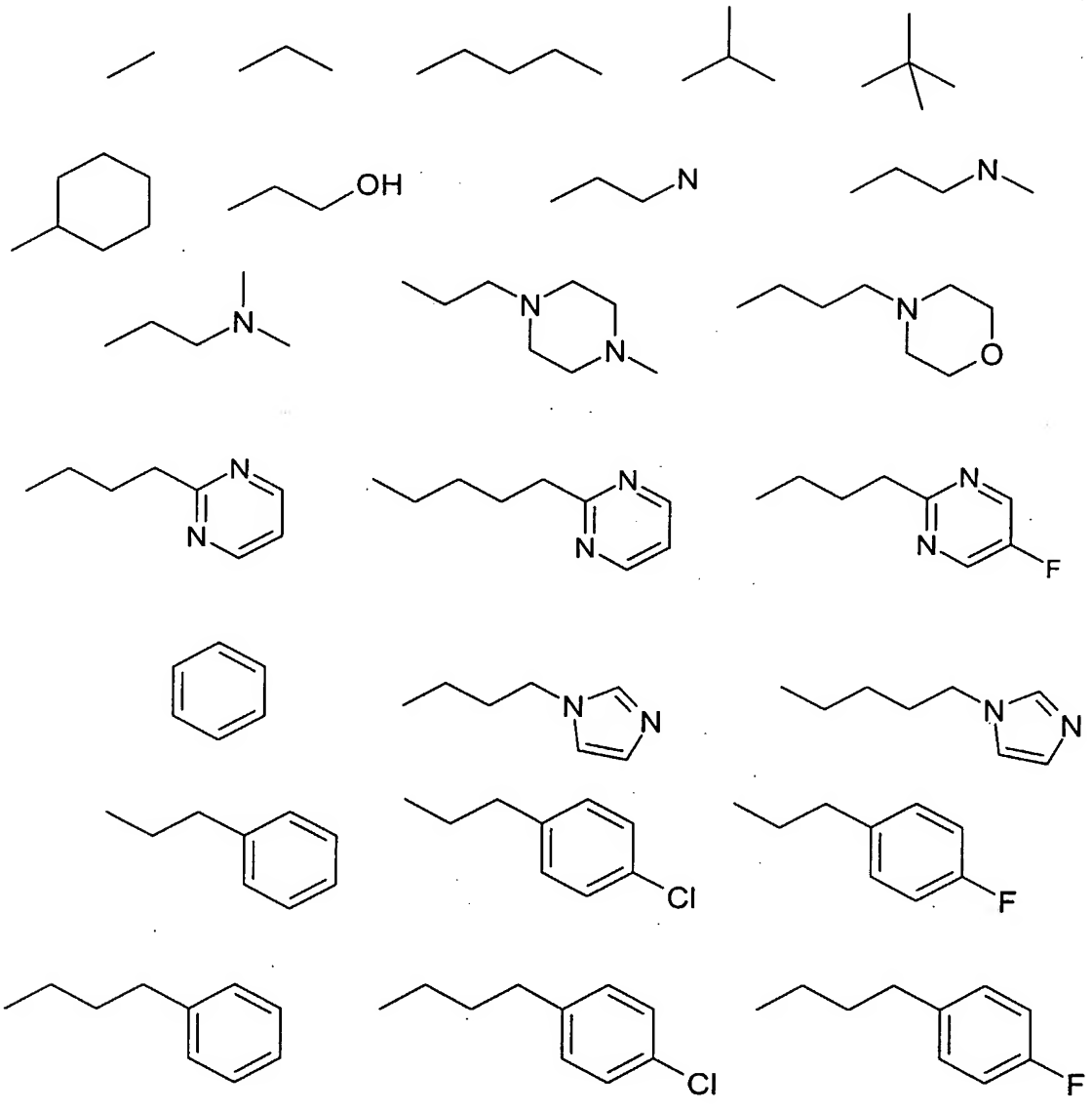
(a) B is a direct bond or O; and Z is SO2N(R6); and R2 is selected from H, (C1-6)alkyl, aryl-(C1-6)alkyl or heteroaryl-(C1-6)alkyl optionally substituted with halo, haloalkyl, hydroxy, alkoxy, haloalkoxy, amino, aminoalkyl, N-alkylamino, N,N-dialkylamino, (N-alkylamino)alkyl, (N,N-dialkylamino)alkyl, alkylsulfonyl, aminosulfonyl, N-alkylamino-sulfonyl, N,N-dialkylamino-sulfonyl, amido, N-alkylamido, N,N-dialkylamido, cyano, sulfonamino, alkyl-sulfonamino, amidino, N-aminosulfone-amidino, guanidino, N-cyano-guanidino, thioguanidino, 2-nitroguanidino, 2-nitro-ethene-1,1-diamino, caboxy, alkylcarboxy; and each of R3 and R4 is H; and R6 is H, benzyl or methylenepyridine; or

(b) Z is $SO_2N(R6)$, and R3 is H, and R4 is H (compounds of the formula II') wherein R2 is not optionally substituted; preferably G1 and G2 are each selected from an aryl or a heteroaryl:

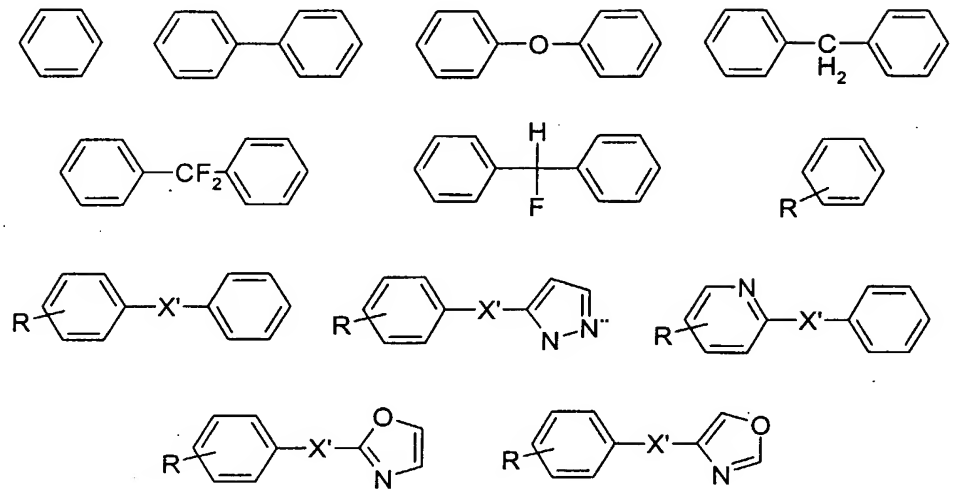


II'

Suitable values for R2 include the following:

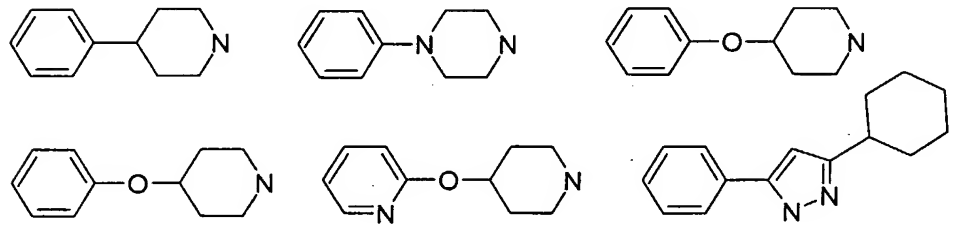


Suitable values for R5 include the following:



X' = a bond, O, CH2, CHF, CF2

R= F, Cl, Br, CF3, CF3O, CH3O, OH, CF3CH2



It will be appreciated that the particular substituents and number of substituents in compounds of the invention are selected so as to avoid sterically undesirable combinations.

Each exemplified compound represents a particular and independent aspect of the invention.

Where optically active centres exist in the compounds of the invention, we disclose all individual optically active forms and combinations of these as individual specific embodiments of the invention, as well as their corresponding racemates. Racemates may be separated into individual optically active forms using known procedures (cf. Advanced

Organic Chemistry: 3rd Edition: author J March, p104-107) including for example the formation of diastereomeric derivatives having convenient optically active auxiliary species followed by separation and then cleavage of the auxiliary species.

It will be appreciated that the compounds according to the invention may contain one or more asymmetrically substituted carbon atoms. The presence of one or more of these asymmetric centres (chiral centres) in a compound of formula I can give rise to stereoisomers, and in each case the invention is to be understood to extend to all such stereoisomers, including enantiomers and diastereomers, and mixtures including racemic mixtures thereof.

Where tautomers exist in the compounds of the invention, we disclose all individual tautomeric forms and combinations of these as individual specific embodiments of the invention.

As previously outlined the compounds of the invention are metalloproteinase inhibitors, in particular they are inhibitors of MMP12. Each of the above indications for the compounds of the formula I represents an independent and particular embodiment of the invention.

Certain compounds of the invention are of particular use as inhibitors of MMP13 and/or MMP9 and/or MMP8 and/or MMP3.

Compounds of the invention show a favourable selectivity profile. Whilst we do not wish to be bound by theoretical considerations, the compounds of the invention are believed to show selective inhibition for any one of the above indications relative to any MMP1 inhibitory activity, by way of non-limiting example they may show 100-1000 fold selectivity over any MMP1 inhibitory activity.

The compounds of the invention may be provided as pharmaceutically acceptable salts. These include acid addition salts such as hydrochloride, hydrobromide, citrate and maleate salts and salts formed with phosphoric and sulphuric acid. In another aspect suitable salts are base salts such as an alkali metal salt for example sodium or potassium, an alkaline earth metal salt for example calcium or magnesium, or organic amine salt for example triethylamine.

They may also be provided as *in vivo* hydrolysable esters. These are pharmaceutically acceptable esters that hydrolyse in the human body to produce the parent compound. Such

esters can be identified by administering, for example intravenously to a test animal, the compound under test and subsequently examining the test animal's body fluids. Suitable *in vivo* hydrolysable esters for carboxy include methoxymethyl and for hydroxy include formyl and acetyl, especially acetyl.

In order to use a metalloproteinase inhibitor compound of the invention (a compound of the formula I or II) or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof for the therapeutic treatment (including prophylactic treatment) of mammals including humans, it is normally formulated in accordance with standard pharmaceutical practice as a pharmaceutical composition.

Therefore in another aspect the present invention provides a pharmaceutical composition which comprises a compound of the invention (a compound of the formula I or II) or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester and pharmaceutically acceptable carrier.

The pharmaceutical compositions of this invention may be administered in standard manner for the disease or condition that it is desired to treat, for example by oral, topical, parenteral, buccal, nasal, vaginal or rectal adminstration or by inhalation. For these purposes the compounds of this invention may be formulated by means known in the art into the form of, for example, tablets, capsules, aqueous or oily solutions, suspensions, emulsions, creams, ointments, gels, nasal sprays, suppositories, finely divided powders or aerosols for inhalation, and for parenteral use (including intravenous, intramuscular or infusion) sterile aqueous or oily solutions or suspensions or sterile emulsions.

In addition to the compounds of the present invention the pharmaceutical composition of this invention may also contain, or be co-administered (simultaneously or sequentially) with, one or more pharmacological agents of value in treating one or more diseases or conditions referred to hereinabove.

The pharmaceutical compositions of this invention will normally be administered to humans so that, for example, a daily dose of 0.5 to 75 mg/kg body weight (and preferably of 0.5 to 30 mg/kg body weight) is received. This daily dose may be given in divided doses as necessary, the precise amount of the compound received and the route of administration depending on the weight, age and sex of the patient being treated and on the particular disease or condition being treated according to principles known in the art.

Typically unit dosage forms will contain about 1 mg to 500 mg of a compound of this invention.

Therefore in a further aspect, we provide a compound of the formula I or a pharmaceutically acceptable salt or in vivo hydrolysable ester thereof for use in a method of therapeutic treatment of the human or animal body or for use as a therapeutic agent. We disclose use in the treatment of a disease or condition mediated by one or more metalloproteinase enzymes. In particular we disclose use in the treatment of a disease or condition mediated by MMP12 and/or MMP13 and/or MMP9 and/or MMP8 and/or MMP3; especially use in the treatment of a disease or condition mediated by MMP12 or MMP9; most especially use in the treatment of a disease or condition mediated by MMP12.

In particular we provide a compound of the formula II or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof for use in a method of therapeutic treatment of the human or animal body or for use as a therapeutic agent (such as use in the treatment of a disease or condition mediated by MMP12 and/or MMP13 and/or MMP9 and/or MMP8 and/or MMP3; especially MMP12 or MMP9; most especially MMP12).

In yet a further aspect we provide a method of treating a metalloproteinase mediated disease or condition which comprises administering to a warm-blooded animal a therapeutically effective amount of a compound of the formula I or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof. We also disclose the use of a compound of the formula I or a pharmaceutically acceptable salt or *in vivo* hydrolysable precursor thereof in the preparation of a medicament for use in the treatment of a disease or condition mediated by one or more metalloproteinase enzymes.

For example we provide a method of treating a metalloproteinase mediated disease or condition which comprises administering to a warm-blooded animal a therapeutically effective amount of a compound of the formula II (or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof). We also provide the use of a compound of the formula II (or a pharmaceutically acceptable salt or in vivo hydrolysable precursor thereof) in the

preparation of a medicament for use in the treatment of a disease or condition mediated by one or more metalloproteinase enzymes.

Metalloproteinase mediated diseases or conditions include asthma, rhinitis, chronic obstructive pulmonary diseases (COPD), arthritis (such as rheumatoid arthritis and osteoarthritis), atherosclerosis and restenosis, cancer, invasion and metastasis, diseases involving tissue destruction, loosening of hip joint replacements, periodontal disease, fibrotic disease, infarction and heart disease, liver and renal fibrosis, endometriosis, diseases related to the weakening of the extracellular matrix, heart failure, aortic aneurysms, CNS related diseases such as Alzheimer's disease and Multiple Sclerosis (MS), hematological disorders.

Preparation of the compounds of the invention

In another aspect the present invention provides a process for preparing a compound of the formula I or II or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as described in (a) to (c) below. It will be appreciated that many of the relevant starting materials are commercially or otherwise available or may be synthesised by known methods or may be found in the scientific literature.

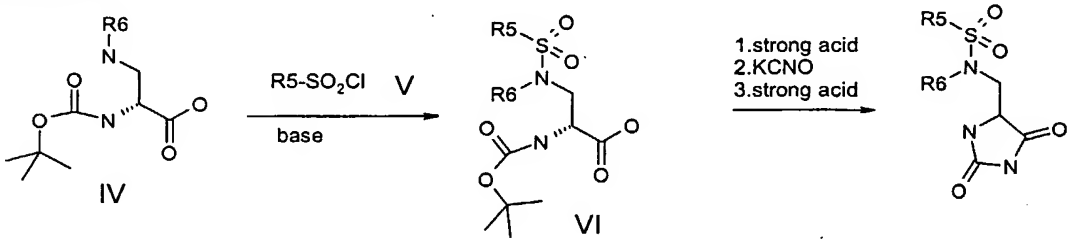
(a) Compounds of formula I in which Y1 and Y2 are each O, Z is SO2N(R6), A is a direct bond, X is NR1, R1 is H, R2 is H, m is 1, R3 is H, R4 is H, and R5 and R6 are defined as in formula I may be prepared according to Scheme 1.

When R6 is H, an N^1-BOC-D-diaminopropionic acid derivative of formula IV is reacted with suitable sulfonyl chloride of formula V in basic medium to form sulfonamides of formula VI. Deprotection in acid medium, reaction with potassium cyanate to the corresponding urea and finally cyclization in acid medium yields compounds of formula I.

When R6 is alkyl such as methyl, ethyl, propyl, isopropyl and n-butyl, the N^2 –alkyl-N^1-BOC-D-diaminopropionic acid of formula IV is prepared according to Andruszkiewics, R.: *Pol.J.Chem,* **62**,257, (1988).

When R6 is an optionally substituted benzyl, methylbenzyl, methylpyridyl, methyl heteroaryl, the N^2-substituted amino acid of formula IV is prepared according to *Helv.Chim.Acta,* **46**,327, (1963).

Scheme 1:



The reaction IV-VI is preferably performed in suitable solvent optionally in the presence of base for 1 to 24h at ambient to reflux temperature. Preferably, solvents such as pyridine, dimethylformamide, tetrahydrofurane, acetonitrile or dichlorometane are used with bases like triethylamine, N-methylmorpholine, pyridine or alkali metal carbonates at ambient temperature for 2-16 h reaction time, or until end of reaction is achieved as detected by chromatographic or spectroscopic methods. Reactions of sulfonyl chlorides of formula V with various secondary amines are previously described in the literature, and the variations of the conditions will be evident for those skilled in the art. A variety of compounds of formula V are commercially available or their synthesis is described in the literature. Specific derivatives of formula VI may be made according to known processes by those skilled in the art.

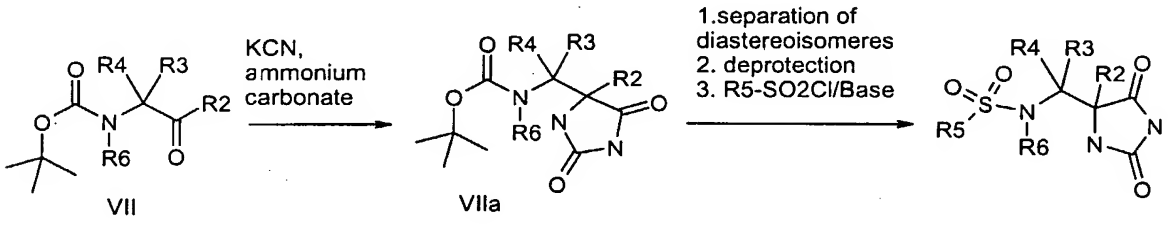
(b) Compounds of formula I in which Y1 and Y2 are each O, Z is SO2N(R6), R6 is H, A is a direct bond, X is NR1, R1 is H, m is 1, and R2, R3, R4 and R5 are defined as in formula I may be prepared according to Scheme 1.

Compounds in which R2 is H, R3 is H and R4 is alkyl or aryl, may be prepared starting from the corresponding BOC N-protected α-amino aldehydes of formula VII, prepared according to *Fehrentz,JA,Castro,B.;* Synthesis, 676, (1983).

Compounds in which R2 is alkyl or aryl, R3 is H and R4 is alkyl or aryl, may be prepared starting from the corresponding BOC N-protected α-amino ketone of formula VII as depicted in Scheme 2., The BOC N-protected α-amino ketones are prepared according to *Nahm,S, Weinreb,SM:* Tetrahedron Lett.**22**,3815,(1981), optionally when R6 is not H, according to *Shuman, Robert T.* US 4448717 A 19840515

Some compounds prepared by the process shown in Scheme 2 are described in Example 3.

Scheme 2:

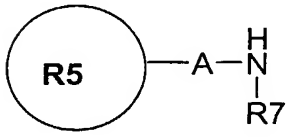


The compounds of formula VII are reacted with alkali cyanide and ammonium carbonate (*Strecker reaction*) to yield the corresponding hydantoins of formula VIIa. The diastereoisomeres can optionally be separated after any of the three remaining synthetic steps: carbamates of formula VIIa and sulfonamide compounds of formula I on silicagel chromatography, after deprotection amino intermediate by chrystallisation. The amine intermediates are optionally used to directly couple with sulfonyl chlorides of formula V as described in the sulfonylation in (a) above, in basic medium to form compounds of formula I.

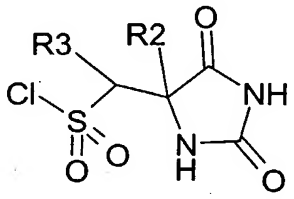
The reaction VII to VIIa is preferably run in a closed steel vessel in an aqueous alcohol solvent at 90-130°C for 3-16 hours or until end of reaction is achieved as detected by chromatographic or spectroscopic methods. Treatment with 1-4 fold excess cyanide salts, preferrably 1-2 equivalents, and 2-6 fold excess of ammonium carbonate, preferrably 4-6 equivalents yields hydantoins of formula VIIa. Deprotection and sulfonylation as in Scheme 1 then yields compounds of formula I.

Amino aldehydes or ketones of formula VII and their protected derivatives are commercially available and other methods to α-amino aldehydes and ketones of formula VII. Specific derivatives of formula VIIa may be made according to known processes by those skilled in the art.

(c) Compounds of formula I in which Y1 and Y2 are each O, X is NR1 (R1=H), Z=N(R7)SO2, m=1, R4=H and R2, R3, R5 and R7 are as described in formula I may be prepared by reacting a compound of formula VIII in which R2, R3, R5,R7 and A are as described in formula I, with sulfonyl chlorides of formula IX in polar aprotic solvents such as THF or DMF in the presence of bases such as alkali carbonates or tertiary alkyl amines or polymeric amines.

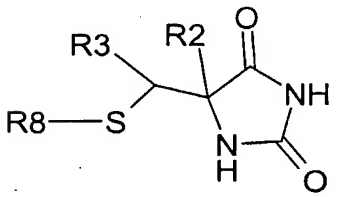


VIII

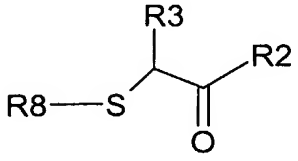


IX

Amines of formula VIII are well known in the literature and are available from numerous commercial sources. Specific new variations of compounds of formula VIII may be made according to known processes by those skilled in the art. The sulfonyl chlorides of formula IX may be prepared by chlorine oxidation of sulfides or disulfides of formula X, where R8 is a group such as hydrogen, isopropyl, benzyl or a sulfide such that formula X comprises of a symmetrical disulfide.



X



XI

Sulfides of formula X may be made from cysteine or cystine (R2, R3=H) and their esters by sequential treatment with alkali cyanate and strong acids like potassium cyanate and hydrochloric acid. Alternatively, sulfides of formula X may be prepared by subjecting

ketones of formula XI to conditions as described in the transformation of VII to VIIa above in (a).

The compounds of the invention may be evaluated for example in the following assays:

Isolated Enzyme Assays

Matrix Metalloproteinase family including for example MMP12, MMP13.

Recombinant human MMP12 catalytic domain may be expressed and purified as described by Parkar A.A. *et al*, (2000), Protein Expression and Purification, 20:152. The purified enzyme can be used to monitor inhibitors of activity as follows: MMP12 (50 ng/ml final concentration) is incubated for 30 minutes at RT in assay buffer (0.1M Tris-HCl, pH 7.3 containing 0.1M NaCl, 20mM $CaCl_2$, 0.040 mM ZnCl and 0.05% (w/v) Brij 35) using the synthetic substrate Mac-Pro-Cha-Gly-Nva-His-Ala-Dpa-NH2 in the presence or absence of inhibitors. Activity is determined by measuring the fluorescence at λex 328nm and λem 393nm. Percent inhibition is calculated as follows: % Inhibition is equal to the [$Fluorescence_{plus\ inhibitor}$ - $Fluorescence_{background}$] divided by the [$Fluorescence_{minus\ inhibitor}$ - $Fluorescence_{background}$].

Recombinant human proMMP13 may be expressed and purified as described by Knauper *et al.* [V. Knauper *et al.*, (1996) The Biochemical Journal 271:1544-1550 (1996)]. The purified enzyme can be used to monitor inhibitors of activity as follows: purified proMMP13 is activated using 1mM amino phenyl mercuric acid (APMA), 20 hours at 21°C; the activated MMP13 (11.25ng per assay) is incubated for 4-5 hours at 35°C in assay buffer (0.1M Tris-HCl, pH 7.5 containing 0.1M NaCl, 20mM CaCl2, 0.02 mM ZnCl and 0.05% (w/v) Brij 35) using the synthetic substrate 7-methoxycoumarin-4-yl)acetyl.Pro.Leu.Gly.Leu.N-3-(2,4-dinitrophenyl)-L-2,3-diaminopropionyl.Ala.Arg.NH_2 in the presence or absence of inhibitors. Activity is determined by measuring the fluorescence at λex 328nm and λem 393nm. Percent inhibition is calculated as follows: %

Inhibition is equal to the [$Fluorescence_{plus\ inhibitor}$ - $Fluorescence_{background}$] divided by the [$Fluorescence_{minus\ inhibitor}$ - $Fluorescence_{background}$].

A similar protocol can be used for other expressed and purified pro MMPs using substrates and buffers conditions optimal for the particular MMP, for instance as described in C. Graham Knight *et al.*, (1992) FEBS Lett. 296(3):263-266.

Adamalysin family including for example TNF convertase

The ability of the compounds to inhibit proTNFα convertase enzyme may be assessed using a partially purified, isolated enzyme assay, the enzyme being obtained from the membranes of THP-1 as described by K. M. Mohler *et al.*, (1994) Nature 370:218-220. The purified enzyme activity and inhibition thereof is determined by incubating the partially purified enzyme in the presence or absence of test compounds using the substrate 4',5'-Dimethoxy-fluoresceinyl Ser.Pro.Leu.Ala.Gln.Ala.Val.Arg.Ser.Ser.Ser.Arg.Cys(4-(3-succinimid-1-yl)-fluorescein)-NH_2 in assay buffer (50mM Tris HCl, pH 7.4 containing 0.1% (w/v) Triton X-100 and 2mM $CaCl_2$), at 26°C for 18 hours. The amount of inhibition is determined as for MMP13 except λex 490nm and λem 530nm were used. The substrate was synthesised as follows. The peptidic part of the substrate was assembled on Fmoc-NH-Rink-MBHA-polystyrene resin either manually or on an automated peptide synthesiser by standard methods involving the use of Fmoc-amino acids and O-benzotriazol-1-yl-N,N,N',N'-tetramethyluronium hexafluorophosphate (HBTU) as coupling agent with at least a 4- or 5-fold excess of Fmoc-amino acid and HBTU. Ser^1 and Pro^2 were double-coupled. The following side chain protection strategy was employed; Ser^1(But), Gln^5(Trityl), $Arg^{8,12}$(Pmc or Pbf), $Ser^{9,10,11}$(Trityl), Cys^{13}(Trityl). Following assembly, the N-terminal Fmoc-protecting group was removed by treating the Fmoc-peptidyl-resin with in DMF. The amino-peptidyl-resin so obtained was acylated by treatment for 1.5-2hr at 70°C with 1.5-2 equivalents of 4',5'-dimethoxy-fluorescein-4(5)-carboxylic acid [Khanna & Ullman, (1980) Anal Biochem. 108:156-161) which had been preactivated with diisopropylcarbodiimide and 1-hydroxybenzotriazole in DMF]. The dimethoxyfluoresceinyl-peptide was then simultaneously deprotected and cleaved from the resin by treatment with trifluoroacetic acid containing 5% each of water and triethylsilane.

The dimethoxyfluoresceinyl-peptide was isolated by evaporation, trituration with diethyl ether and filtration. The isolated peptide was reacted with 4-(N-maleimido)-fluorescein in DMF containing diisopropylethylamine, the product purified by RP-HPLC and finally isolated by freeze-drying from aqueous acetic acid. The product was characterised by MALDI-TOF MS and amino acid analysis.

Natural Substrates

The activity of the compounds of the invention as inhibitors of aggrecan degradation may be assayed using methods for example based on the disclosures of E. C. Arner *et al.*, (1998) Osteoarthritis and Cartilage 6:214-228; (1999) Journal of Biological Chemistry, 274 (10), 6594-6601 and the antibodies described therein. The potency of compounds to act as inhibitors against collagenases can be determined as described by T. Cawston and A. Barrett (1979) Anal. Biochem. 99:340-345.

Inhibition of metalloproteinase activity in cell/tissue based activity

Test as an agent to inhibit membrane sheddases such as TNF convertase

The ability of the compounds of this invention to inhibit the cellular processing of TNFα production may be assessed in THP-1 cells using an ELISA to detect released TNF essentially as described K. M. Mohler *et al.*, (1994) Nature 370:218-220. In a similar fashion the processing or shedding of other membrane molecules such as those described in N. M. Hooper *et al.*, (1997) Biochem. J. 321:265-279 may be tested using appropriate cell lines and with suitable antibodies to detect the shed protein.

Test as an agent to inhibit cell based invasion

The ability of the compound of this invention to inhibit the migration of cells in an invasion assay may be determined as described in A. Albini *et al.*, (1987) Cancer Research 47:3239-3245.

Test as an agent to inhibit whole blood TNF sheddase activity

The ability of the compounds of this invention to inhibit TNFα production is assessed in a human whole blood assay where LPS is used to stimulate the release of TNFα. Heparinized (10Units/ml) human blood obtained from volunteers is diluted 1:5 with medium (RPMI1640 + bicarbonate, penicillin, streptomycin and glutamine) and incubated (160μl) with 20μl of test compound (triplicates), in DMSO or appropriate vehicle, for 30 min at 37°C in a humidified (5%CO_2/95%air) incubator, prior to addition of 20μl LPS (E. coli. 0111:B4; final concentration 10μg/ml). Each assay includes controls of diluted blood incubated with medium alone (6 wells/plate) or a known TNFα inhibitor as standard. The plates are then incubated for 6 hours at 37°C (humidified incubator), centrifuged (2000rpm for 10 min; 4°C), plasma harvested (50-100μl) and stored in 96 well plates at -70°C before subsequent analysis for TNFα concentration by ELISA.

Test as an agent to inhibit in vitro cartilage degradation

The ability of the compounds of this invention to inhibit the degradation of the aggrecan or collagen components of cartilage can be assessed essentially as described by K. M. Bottomley *et al.*, (1997) Biochem J. 323:483-488.

Pharmacodynamic test

To evaluate the clearance properties and bioavailability of the compounds of this invention an ex vivo pharmacodynamic test is employed which utilises the synthetic substrate assays above or alternatively HPLC or Mass spectrometric analysis. This is a generic test which can be used to estimate the clearance rate of compounds across a range

of species. Animals (e,g. rats, marmosets) are dosed iv or po with a soluble formulation of compound (such as 20% w/v DMSO, 60% w/v PEG400) and at subsequent time points (e.g. 5, 15, 30, 60, 120, 240, 480, 720, 1220 mins) the blood samples are taken from an appropriate vessel into 10U heparin. Plasma fractions are obtained following centrifugation and the plasma proteins precipitated with acetonitrile (80% w/v final concentration). After 30 mins at -20°C the plasma proteins are sedimented by centrifugation and the supernatant fraction is evaporated to dryness using a Savant speed vac. The sediment is reconstituted in assay buffer and subsequently analysed for compound content using the synthetic substrate assay. Briefly, a compound concentration-response curve is constructed for the compound undergoing evaluation. Serial dilutions of the reconstituted plasma extracts are assessed for activity and the amount of compound present in the original plasma sample is calculated using the concentration-response curve taking into account the total plasma dilution factor.

In vivo assessment

Test as an anti-TNF agent

The ability of the compounds of this invention as *ex vivo* TNFα inhibitors is assessed in the rat. Briefly, groups of male Wistar Alderley Park (AP) rats (180-210g) are dosed with compound (6 rats) or drug vehicle (10 rats) by the appropriate route e.g. peroral (p.o.), intraperitoneal (i.p.), subcutaneous (s.c.). Ninety minutes later rats are sacrificed using a rising concentration of CO_2 and bled out via the posterior vena cavae into 5 Units of sodium heparin/ml blood. Blood samples are immediately placed on ice and centrifuged at 2000 rpm for 10 min at 4°C and the harvested plasmas frozen at -20°C for subsequent assay of their effect on TNFα production by LPS-stimulated human blood. The rat plasma samples are thawed and 175µl of each sample are added to a set format pattern in a 96U well plate. Fifty µl of heparinized human blood is then added to each well, mixed and the plate is incubated for 30 min at 37°C (humidified incubator). LPS (25µl; final concentration 10µg/ml) is added to the wells and incubation continued for a further 5.5 hours. Control wells are incubated with 25µl of medium alone. Plates are then centrifuged

for 10 min at 2000 rpm and 200µl of the supernatants are transferred to a 96 well plate and frozen at -20°C for subsequent analysis of TNF concentration by ELISA.

Data analysis by dedicated software calculates for each compound/dose:

Percent inhibition of TNFα= $\frac{\text{Mean TNFα (Controls)} - \text{Mean TNFα (Treated)} \times 100}{\text{Mean TNFα (Controls)}}$

Test as an anti-arthritic agent

Activity of a compound as an anti-arthritic is tested in the collagen-induced arthritis (CIA) as defined by D. E. Trentham *et al.*, (1977) J. Exp. Med. 146,:857. In this model acid soluble native type II collagen causes polyarthritis in rats when administered in Freunds incomplete adjuvant. Similar conditions can be used to induce arthritis in mice and primates.

Test as an anti-cancer agent

Activity of a compound as an anti-cancer agent may be assessed essentially as described in I. J. Fidler (1978) Methods in Cancer Research 15:399-439, using for example the B16 cell line (described in B. Hibner *et al.*, Abstract 283 p75 10th NCI-EORTC Symposium, Amsterdam June 16 – 19 1998).

Test as an anti-emphysema agent

Activity of a compound as an anti-emphysema agent may be assessed essentially as described in Hautamaki *et al* (1997) Science, 277: 2002.

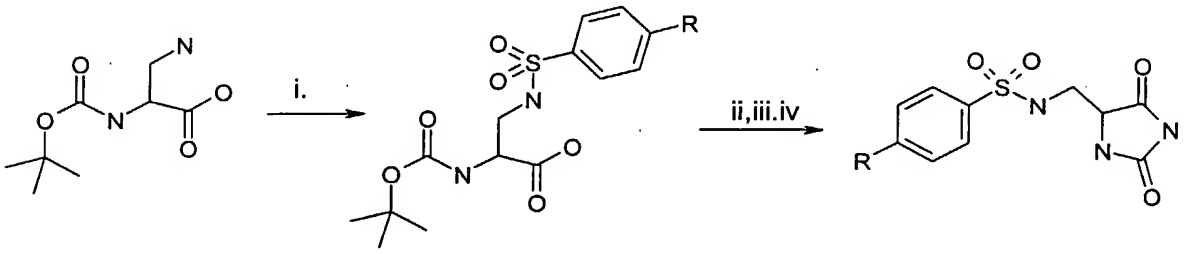
The invention will now be illustrated but not limited by the following Examples:

General analytical methods: ^{1}H-NMR spectra were recorded on either a Varian ^{Unity}*Inova* 400MHz or Varian *Mercury-VX* 300MHz instrument. The central solvent peak of chloroform-*d* (δ_H 7.27 ppm), dimethylsulfoxide-d_6 (δ_H 2.50 ppm) or methanol-d_4 (δ_H 3.31 ppm) were used as internal references. Low resolution mass spectra were obtained on a Agilent 1100 LC-MS system equipped with an APCI ionization chamber.

EXAMPLE 1

***N*-{[(4*S*)-2,5-dioxoimidazolidinyl]methyl}-4-(4- fluorophenoxy) benzenesulfonamide and**

***N*-{[(4*S*)-2,5-dioxoimidazolidinyl]methyl}[1,1'-biphenyl]-4-sulfonamide**



i $C_6H_4SO_2Cl$ ii HCl/dioxane iii KCNO iv wt. HCl, 100°C

R = 4-fluorophenoxy or R = phenyl

To the stirred solution of N-alfa-BOC-(S)-diaminopropionic acid (100 mg,0.5 mmol) in 2.5 ml water containing 0.04g (0.55 mmol) of sodium carbonate was added the soln.of the sulfonyl chloride (0.5 mmol) in 2.5 ml of dioxane.The solution was stirred overnight at room temperature, distributed between ethyl acetate (10 ml) and ca 20% citric acid (10 ml),the water phase was three times reextracted with ethyl acetate,organic extract was washed with brine,dried,evaporated and the residue was treated with 4N HCl in dioxane.The mixture was stirred for 20 min,evaporated and dried in vacuo for 4 hrs at 40 C.Then,the residue was quenched with 3ml of water solution of sodium carbonate (0.08g,

0.85 mmol) and 0.9 g (1.1 mmol) of potassium cyanate was added and the mixture was stirred for 4 hrs at 100 C.After this period,1 ml of conc.HCl as added,stirred for 1 hr at the same temperature and then allowed to stand at room temperature overnight.The crystalls were filtered,washed with dist.water and dried in vacuo (recrystallised from wt.ethanol if necessary)

***N*-{[(4*S*)-2,5-dioxoimidazolidinyl]methyl}-4-(4- fluorophenoxy) benzenesulfonamide**

MS:m/z=380.1

***N*-{[(4*S*)-2,5-dioxoimidazolidinyl]methyl}[1,1'-biphenyl]-4-sulfonamide**

MS:m/z=346.1

1H NMR:(DMSO):3.00 m (1.5H),3.10m(0.6H),(**CH_2**), 4.10 m (1H,**CH**),7.5 m (3H),7.70d (2H),7.4 s (4H).

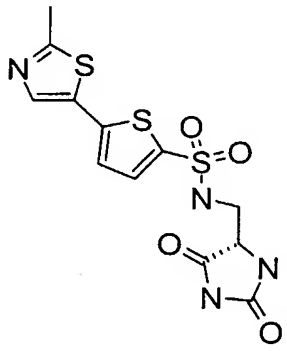
EXAMPLE 2

Compounds of formula I were prepared wherein Y1 is O, Y2 is O, X is NR1, R1 is H, R2 is H, m is 1, R3 is H, R4 is H, Z is $SO_2N(R6)$, R6 is H, (C1-4)alkyl, methylbenzyl, or methylpyridyl, A is a direct bond, and R5 varies.

The syntheses were performed in parallel on 20-well plate manually operated. The amino acid (20 um) was dissolved in 5 ml water containing 6.36 mg (60 um) of sodium carbonate. 0.5 ml of the solution was pipetted to each well, followed by 0.5 ml of dioxane solution containing 20 um of corresponding sulfonyl chloride. The reaction mixture was shaken for 18 hrs at room temperature, diluted with 2 ml of methanol and treated with 20 mg of Lewatite S100 in each well (acid form) for 5 min. Then all reaction mixtures was filtered, evaporated in vacuo and the evaporate was treated with 1 ml of 4 N HCl in dioxane for 30 min, evaporated in vacuo and 0.5 ml of 0.5 M wt. solution of potassium cyanate was added and heated to 100°C for 3 hrs. Then 10 mg of Lewatite S100 (acid form) was added to each well after being cooled to room temperature, followed by 2 ml of methanol, evaporated in vacuo and threated with trifluoroacetic acid at 80°C for 2 hrs. After being evaporated, the residue was purified by flash chromatography on silica

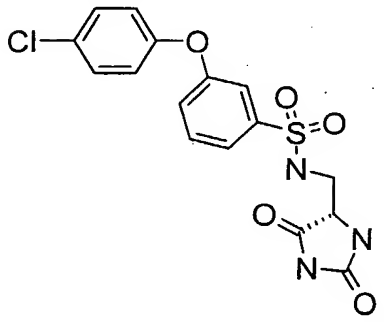
using ethyl acetate-methanol gradient (up to 10% MeOH). The purity and mol.weight was monitored by HPLC-MS. Yields : 0.5-1 mg per each well.

5-(2-Methyl-thiazol-5-yl)-thiophene-2-sulfonic acid (2,5-dioxo-imidazolidin-4-ylmethyl)-amide



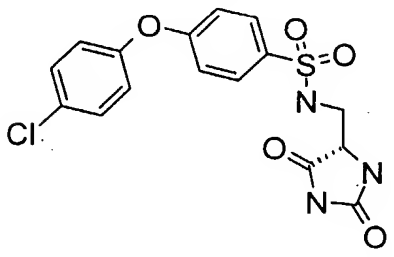
LC-MS (APCI) $M^+ + H^+ = 373.4$ (m/z)

3-(4-Chloro-phenoxy)*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



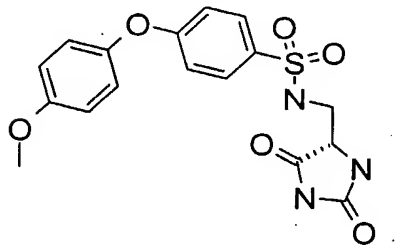
LC-MS (APCI) $M^+ + H^+ = 396.8$(m/z)

4-(4-Chloro-phenoxy)*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



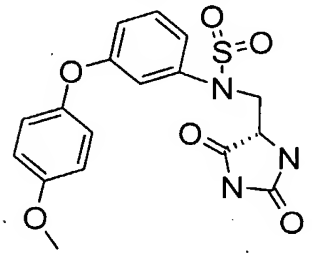
LC-MS (APCI) $M^+ + H^+ = 396.8$(m/z)

***N*-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(4-methoxy-phenoxy)-benzenesulfonamide**



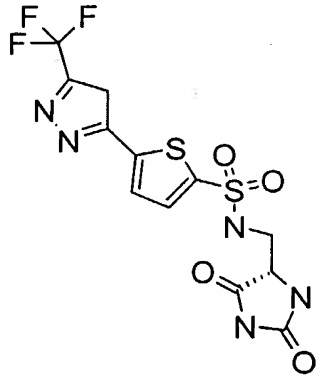
LC-MS (APCI) $M^+ + H^+ = 392.6$(m/z)

***N*-(2,5-Dioxo-imidazolidin-4-ylmethyl)-3-(4-methoxy-phenoxy)-benzenesulfonamide**



LC-MS (APCI) $M^+ + H^+ = 392.6$(m/z)

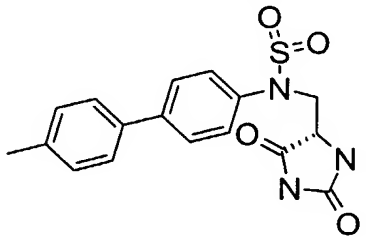
5-(5-Trifluoromethy*H*-pyrazol-3-yl)-thiophene-2-sulfonic acid (2,5-dioxo-imidazolidin-4-ylmethyl)-amide



LC-MS (APCI) $M^+ + H^+ = 410.4$(m/z)

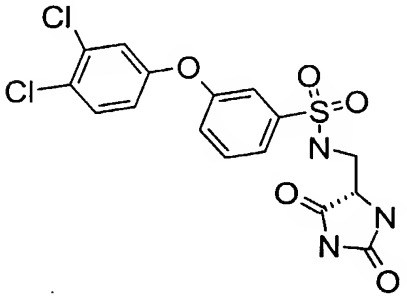
***N*-(2,5-Dioxo-imidazolidin-4-ylmethyp -4-**

-tolyloxy-benzenesulfonamide



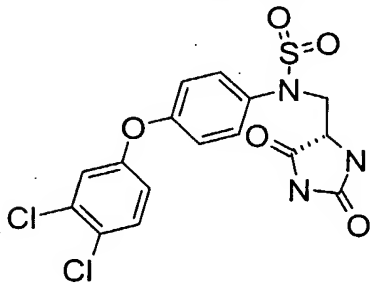
LC-MS (APCI) $M^+ + H^+ = 376.4$(m/z)

3-(3,4-Dichloro-phenoxy)- *N* -(dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



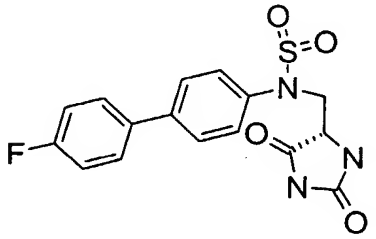
LC-MS (APCI) $M^+ + H^+ = 430.6$(m/z)

4-(3,4-Dichloro-phenoxy)- *N* -(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



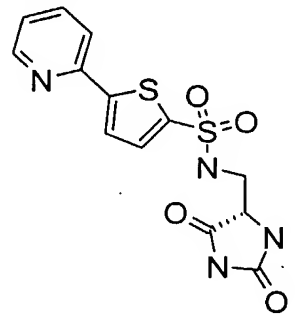
LC-MS (APCI) $M^+ + H^+ = 430.6$(m/z)

4'-Fluoro-biphenyl-4-sulfonic acid (2,5-dioxo-imidazolidin-4-ylmethyl)-amide



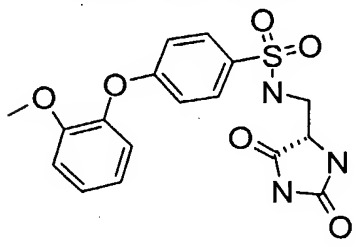
LC-MS (APCI) $M^+ + H^+ = 364.4$(m/z)

5-Pyridin-2-yl-thiophene-2-sulfonic acid (2,5-dioxo-imidazolidin-4-ylmethyl)-amide



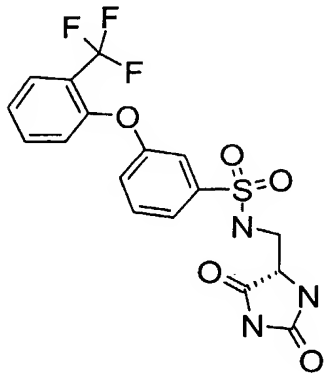
LC-MS (APCI) $M^+ + H^+ = 353.4$(m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(2-methoxy-phenoxy)-benzenesulfonamide



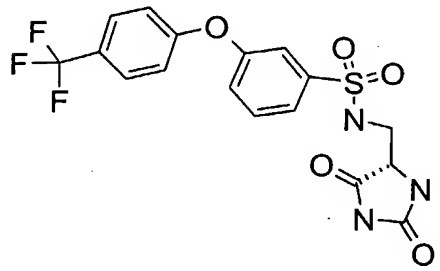
LC-MS (APCI) $M^+ + H^+ = 392.5$(m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-3-(2-trifluoromethyl-phenoxy)-benzenesulfonamide



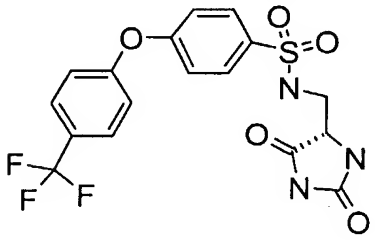
LC-MS (APCI) $M^+ + H^+ = 430.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-3-(4-trifluoromethyl-phenoxy)-benzenesulfonamide



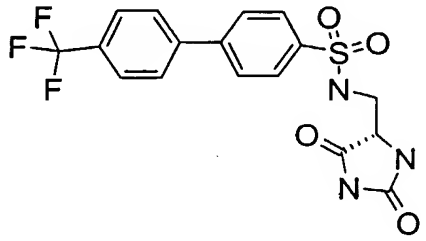
LC-MS (APCI) $M^+ + H^+ = 430.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(4-trifluoromethyl-phenoxy)-benzenesulfonamide



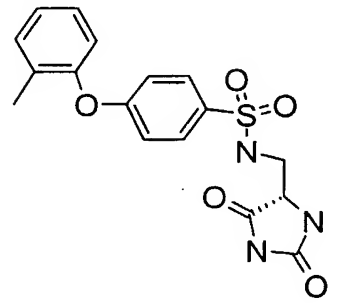
LC-MS (APCI) $M^+ + H^+ = 430.4$ (m/z)

4'-Trifluoromethyl-biphenyl-4-sulfonic acid (2,5-dioxo-imidazolidin-4-ylmethyl)-amide



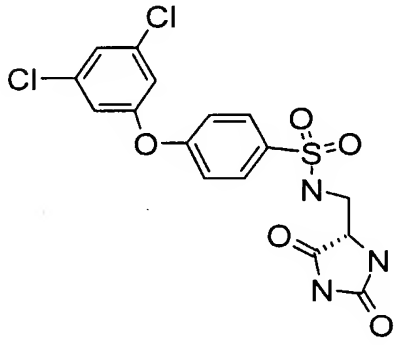
LC-MS (APCI) $M^+ + H^+ = 414.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-*o*-tolyloxy-benzenesulfonamide



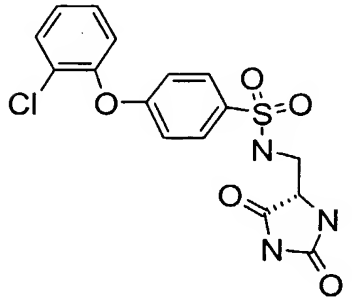
LC-MS (APCI) $M^+ + H^+ = 376.4$ (m/z)

4-(3,5-Dichloro-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



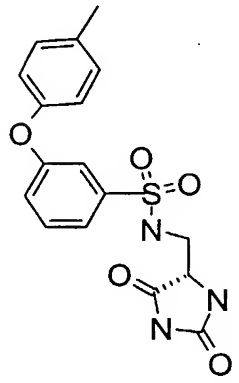
LC-MS (APCI) $M^+ + H^+ = 431.3$ (m/z)

4-(2-Chloro-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



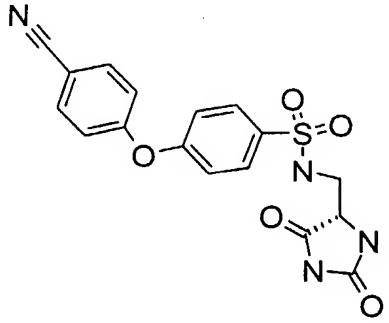
LC-MS (APCI) $M^+ + H^+ = 396.8$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-3-*p*-tolyloxy-benzenesulfonamide



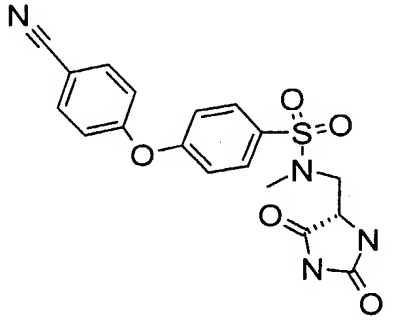
LC-MS (APCI) $M^+ + H^+ = 376.4$ (m/z)

4-(4-Cyano-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



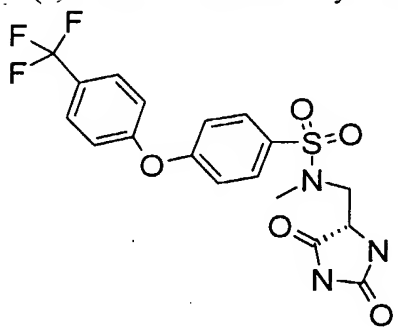
LC-MS (APCI) $M^+ + H^+ = 387.4$ (m/z)

4-(4-Cyano-phenoxy)- *N* -(2,5-dioxo-imidazolidin-4-ylmethyl)- *N* -methyl-benzenesulfonamide



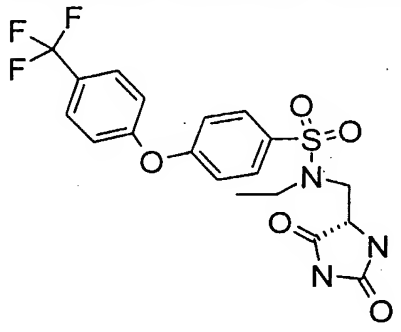
LC-MS (APCI) $M^+ + H^+ = 401.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-methyl-4-(4-trifluoromethyl-phenoxy)-benzenesulfonamide



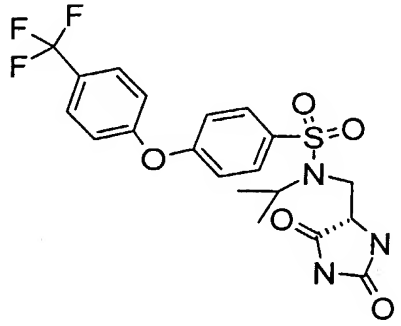
LC-MS (APCI) $M^+ + H^+ = 444.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-4-(4-trifluoromethyl-phenoxy)-benzenesulfonamide



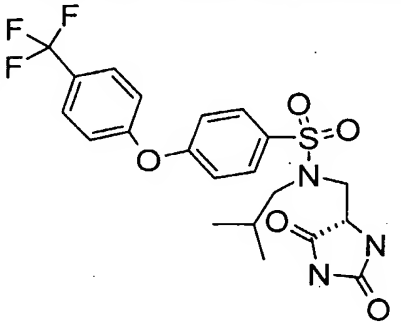
LC-MS (APCI) $M^+ + H^+ = 458.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-isopropyl-4-(4-trifluoromethyl-phenoxy)-benzenesulfonamide



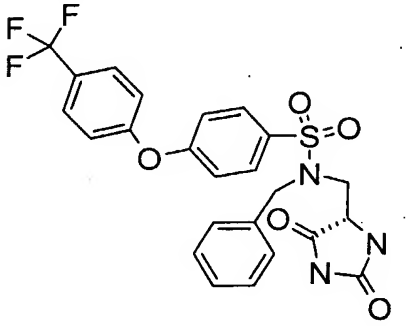
LC-MS (APCI) $M^+ + H^+ = 472.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-isobutyl-4-(4-trifluoromethyl-phenoxy)-benzenesulfonamid



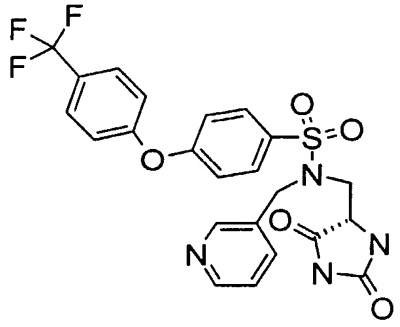
LC-MS (APCI) $M^+ + H^+ = 486.5$ (m/z)

N-Benzyl-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-4-(4-trifluoromethyl-phenoxy)-benzenesulfonamide



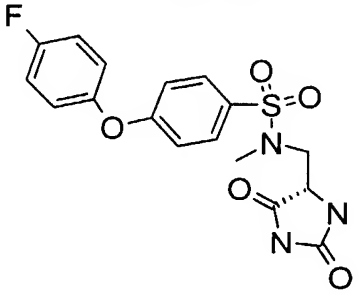
LC-MS (APCI) $M^+ + H^+ = 520.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-pyridin-3-ylmethyl-4-(4-trifluoromethyl-phenoxy)-benzene



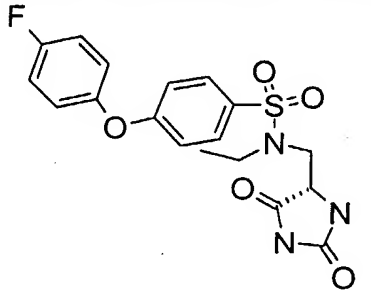
LC-MS (APCI) $M^+ + H^+ = 521.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(4-fluoro-phenoxy)-*N*-methyl-benzenesulfonamide



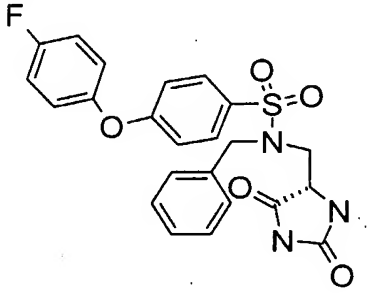
LC-MS (APCI) $M^+ + H^+ = 394.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-4-(4-fluoro-phenoxy)-benzenesulfonamide



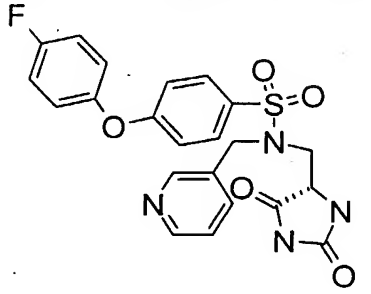
LC-MS (APCI) $M^+ + H^+ = 408.4$ (m/z)

N-Benzyl-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-4-(4-fluoro-phenoxy)-benzenesulfonamide



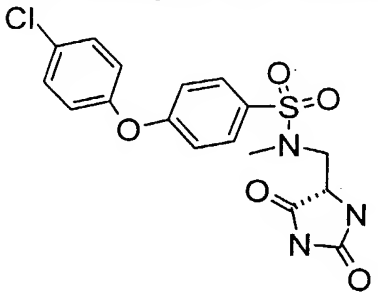
LC-MS (APCI) $M^+ + H^+ = 470.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(4-fluoro-phenoxy)-*N*-pyridin-3-ylmethyl-benzenesulfonami



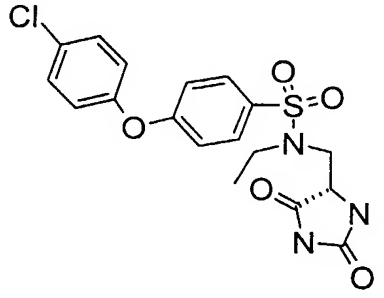
LC-MS (APCI) $M^+ + H^+ = 471.5$ (m/z)

4-(4-Chloro-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-*N*-methyl-benzenesulfonamide



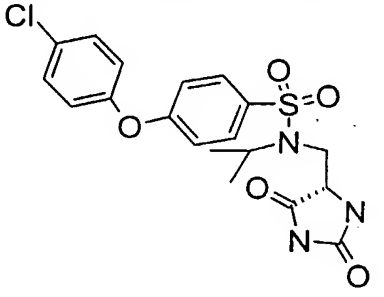
LC-MS (APCI) $M^+ + H^+ = 410.5$ (m/z)

4-(4-Chloro-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-benzenesulfonamide



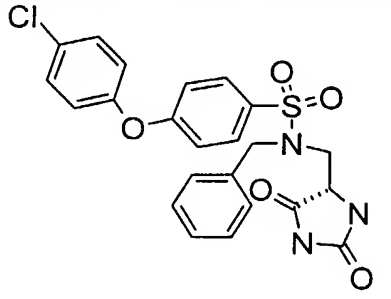
LC-MS (APCI) $M^+ + H^+ = 424.88$ (m/z)

4-(4-Chloro-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-*N*-isopropyl-benzenesulfonamide



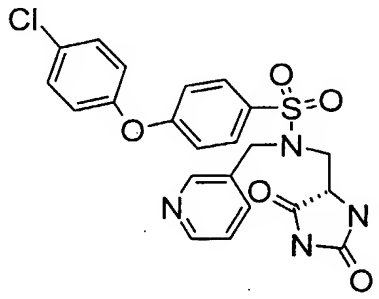
LC-MS (APCI) $M^+ + H^+ = 424.88$ (m/z)

N-Benzyl-4-(4-chloro-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



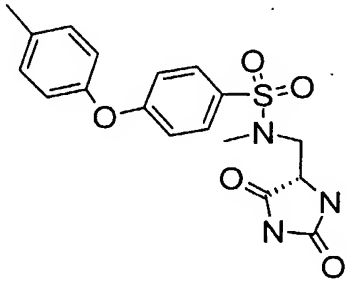
LC-MS (APCI) $M^+ + H^+ = 486.9$ (m/z)

4-(4-Chloro-phenoxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-*N*-pyridin-3-ylmethyl-benzenesulfonamide



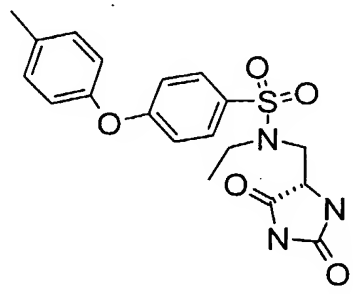
LC-MS (APCI) $M^+ + H^+ = 487.9$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-methyl-4-*p*-tolyloxy-benzenesulfonamide



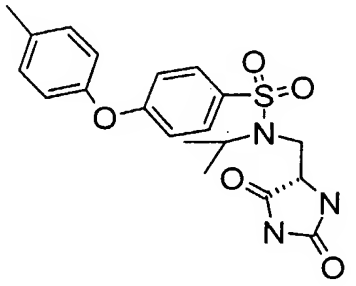
LC-MS (APCI) $M^+ + H^+ = 390.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-4-*p*-tolyloxy-benzenesulfonamide



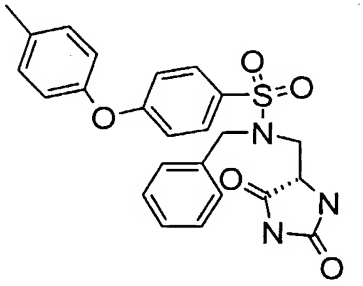
LC-MS (APCI) $M^+ + H^+ = 404.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-isopropyl-4-*p*-tolyloxy-benzenesulfonamide



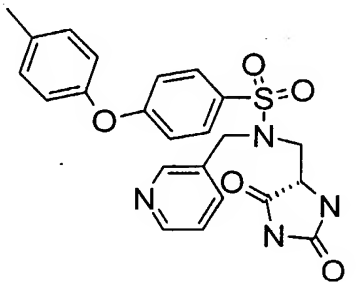
LC-MS (APCI) $M^+ + H^+ = 418.5$ (m/z)

N-Benzyl-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-4-*p*-tolyloxy-benzenesulfonamide



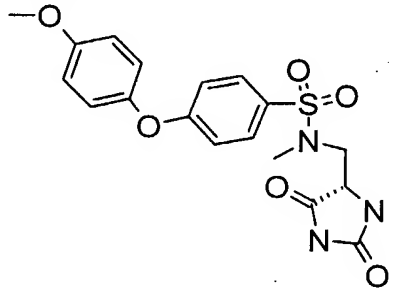
LC-MS (APCI) $M^+ + H^+ = 466.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-pyridin-3-ylmethyl-4-*p*-tolyloxy-benzenesulfonamide



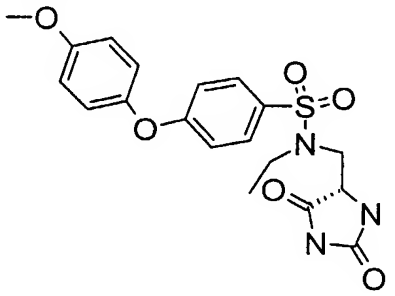
LC-MS (APCI) $M^+ + H^+ = 467.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(4-methoxy-phenoxy)-*N*-methyl-benzenesulfonamide



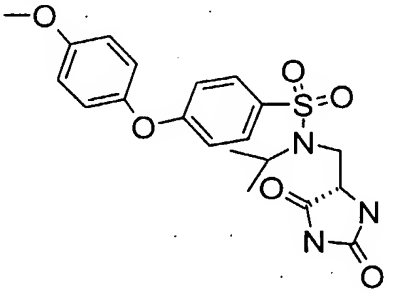
LC-MS (APCI) $M^+ + H^+ = 406.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-4-(4-methoxy-phenoxy)-benzenesulfonamide



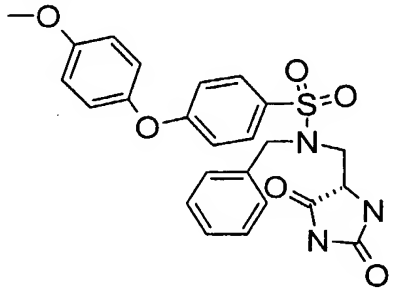
LC-MS (APCI) $M^+ + H^+ = 420.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-isopropyl-4-(4-methoxy-phenoxy)-benzenesulfonamide



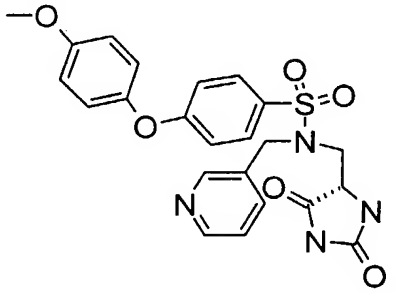
LC-MS (APCI) $M^+ + H^+ = 433.5$ (m/z)

N-Benzyl-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-4-(4-methoxy-phenoxy)-benzenesulfonamide



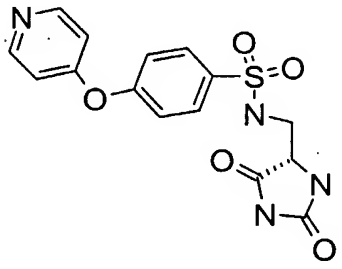
LC-MS (APCI) $M^+ + H^+ = 482.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(4-methoxy-phenoxy)-*N*-pyridin-3-ylmethyl-benzenesulfonam



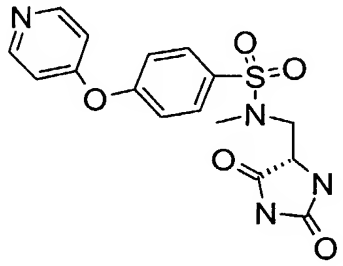
LC-MS (APCI) $M^+ + H^+ = 483.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(pyridin-4-yloxy)-benzenesulfonamide



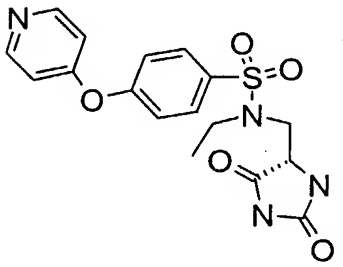
LC-MS (APCI) $M^+ + H^+ = 363.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-methyl-4-(pyridin-4-yloxy)-benzenesulfonamide



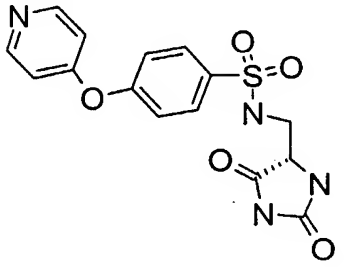
LC-MS (APCI) $M^+ + H^+ = 377.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-4-(pyridin-4-yloxy)-benzenesulfonamide



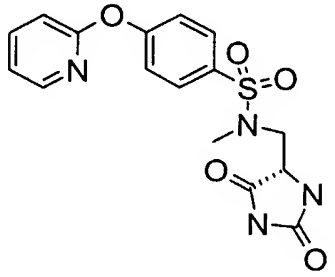
LC-MS (APCI) $M^+ + H^+ = 363.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(pyridin-4-yloxy)-benzenesulfonamide



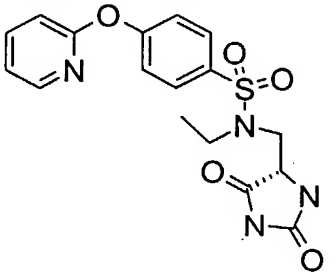
LC-MS (APCI) $M^+ + H^+ = 363.5$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(pyridin-2-yloxy)-benzenesulfonamide



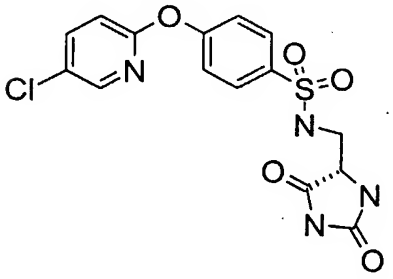
LC-MS (APCI) $M^+ + H^+ = 376.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-4-(pyridin-2-yloxy)-benzenesulfonamide



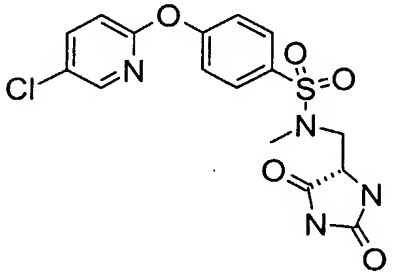
LC-MS (APCI) $M^+ + H^+ = 391.4$ (m/z)

4-(5-Chloro-pyridin-2-yloxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-benzenesulfonamide



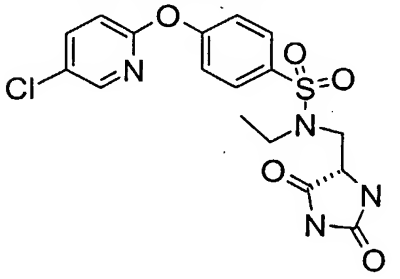
LC-MS (APCI) $M^+ + H^+ = 397.8$ (m/z)

4-(5-Chloro-pyridin-2-yloxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-*N*-methyl-benzenesulfonamide



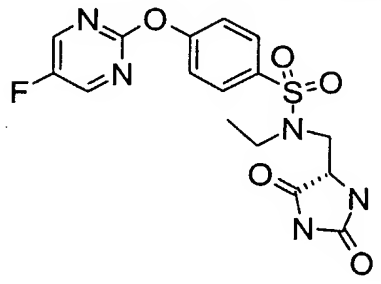
LC-MS (APCI) $M^+ + H^+ = 410.8$ (m/z)

4-(5-Chloro-pyridin-2-yloxy)-*N*-(2,5-dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-benzenesulfonamide



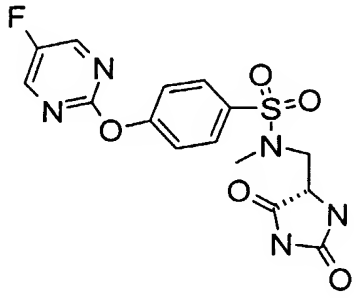
LC-MS (APCI) $M^+ + H^+ = 425.8$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-*N*-ethyl-4-(5-fluoro-pyrimidin-2-yloxy)-benzenesulfonamide



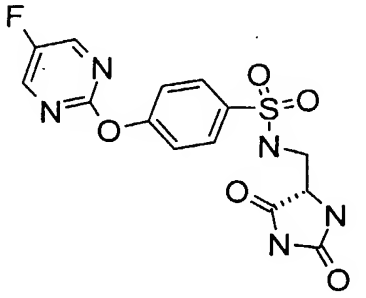
LC-MS (APCI) $M^+ + H^+ = 409.8$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(5-fluoro-pyrimidin-2-yloxy)-*N*-methyl-benzenesulfonamide



LC-MS (APCI) $M^+ + H^+ = 396.4$ (m/z)

N-(2,5-Dioxo-imidazolidin-4-ylmethyl)-4-(5-fluoro-pyrimidin-2-yloxy)-benzenesulfonamide



LC-MS (APCI) $M^+ + H^+ = 382.4$ (m/z)

EXAMPLE 3

Compounds were prepared according to Scheme 2 as shown in the description above.

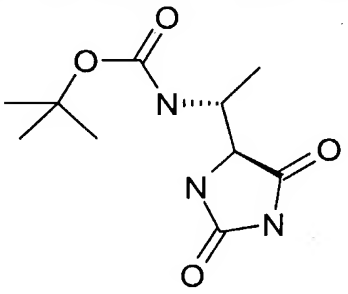
(a) **Preparation of starting materials (aldehydes or ketones)**

Aldehydes were prepared according to the procedure described by *Fehrentz JA and Castro B,* Synthesis, 676, (1983). Ketones were prepared according to the procedure described by *Nahm S and Weinreb SM :*Tetrahedron Lett.**22,** 3815, (1981).

(b) **Preparation of intermediate hydantoins**

The aldehyde or ketone (5 mmol) was dissolved in 50% water ethanol (10 ml) and 0.55 g (10 mmol) of sodium cyanide and 2.7 g (25 mmol) of ammonium carbonate was added and the mixture was heated in the sealed tube to 80°C for 6 hrs. Then it was cooled, pH was adjusted to 4 and it was evaporated in vacuo. The residue was distributed between water (10 ml) and ethyl acetate and water phase was 3-times re-extracted with ethyl acetate, then evaporated and diastereoisomeres were separated by silica chromatography (grad.TBME-methanol 0-10% MeOH). The following hydantoins were prepared.

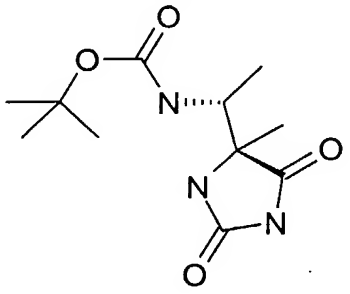
R-1-(2,5-dioxoimidazolidin-4-S-yl)-ethyl carbamic acid *tert.* butylester



LC-MS(APCI):) $M^+ + H^+ = 244.4$,) $M^+ - 56$ (isobutylene) 188.6,) M^+-BOC=144.4 (main peak)

H-NMR ($CDCl_3$ .ppm):1.23d (3H),1.45s (9.1H),4.36m(1.1H),5.30bs(1.1H),10.1bs (1.3H)

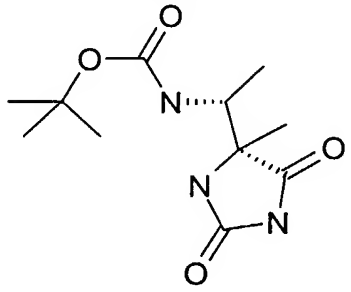
R-1-(4-Methyl-2,5dioxoimidazolin-4-S-yl)ethyl carbamoic acid



LC-MS(APCI):) $M^+ + H^+ = 258.3$,) $M^+ - 56$ (-isobutylene) 202.3,) M^+-BOC=158.3 (main peak)

H-NMR ($CDCl_3$ .ppm):1.22d (3H),1.44s (9.2H),1.58s(3.1H), 3.95m(0.9H),5.5bs (1.5H),7.9bs(0.8H)

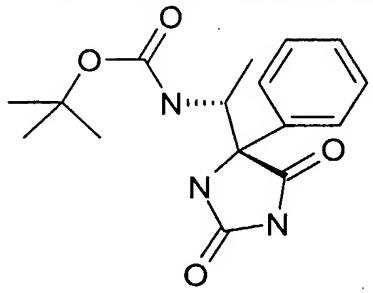
R-1-(4-Methyl-2,5dioxoimidazolin-4-R-yl)ethyl carbamoic acid *tert*-butylester



LC-MS(APCI):) $M^+ + H^+ = 258.3$,) M^+-56 (-isobutylene) 202.3,) M^+-BOC=158.3 (main peak)

H-NMR ($CDCl_3$ .ppm):1.29d (3H),1.54s (9.1H),1.50s(2.95H),4.25m(1.1H),5.5bs (1.8H),7.9bs(0.6H)

R-1-(2,5-dioxo-4-phenylimidazolidin-4-S-yl)-ethyl carbamoic acid *tert*-butyl ester.



LC-MS(APCI):) $M^+ + H^+ = 320.3$) M^+-56 (-isobutylene) 264.3,) M^+-BOC=230.3 (main peak)

H-NMR ($CDCl_3$ .ppm):1.31d(3H),1.35s (9.2H),4.65m(0.9H),6.10 d (0.94H), 7.25m(3.2H),7.60d (2.05H)

tert-butyl (2S)-2-[(4R)-2,5-dioxoimidazolidin-4-yl]pyrrolidine-1-carboxylate

LC-MS: $M^+ + H^+ = 170.0$ (M^+-BOC)

NMR: ($CDCl_3$ .ppm):1.26 s (9H),1.7-1.9m (3.37H),2.1-2.2m (0.84H),3.35-3,44m (1.82H), 4.1 bs (1.1H),

tert-butyl (2S)-2-[(4S)-2,5-dioxoimidazolidin-4-yl]pyrrolidine-1-carboxylate
LC-MS: $M^+ + H^+ = 170.0$ (M^+-BOC)
H-NMR: ($CDCl_3$ .ppm):1.27 s (9H),1.65-2.0 m (broad),(4.47H),3.55m(1.15H,), 3.62m (0.55H),4.4 m (0.87H),

tert-butyl (2R)-2-[(4S)-2,5-dioxoimidazolidin-4-yl]pyrrolidine-1-carboxylate
LC-MS: $M^+ + H^+ = 170.0$ (M^+-BOC)
H-NMR: ($CDCl_3$ .ppm):1.47 s (9H), 1.7-2.2m (broad) 4.30H,3.6 m (1.12H),3.8m (078H,3.6m(1.1H),

tert-butyl (2R)-2-[(4R)-2,5-dioxoimidazolidin-4-yl]pyrrolidine-1-carboxylate
LC-MS: $M^+ + H^+ = 170.0$ (M^+-BOC)
H-NMR: ($CDCl_3$ .ppm):1.47 s (9H), 1.7-2.2m (broad) 4.30H,3.6 m (1.12H),3.8m (078H,3.6m(1.1H),

tert-butyl (2R)-2-[(4S)-4-methyl-2,5-dioxoimidazolidin-4-yl]pyrrolidine-1-carboxylate
LC-MS: $M^+ + H^+ = 183.1$ (M^+-BOC)
H-NMR: ($CDCl_3$ .ppm):1.4 s (9H)1.50s(3.2H), 1.65-2.1m (broad) 4.20H,3.4 m (1.1H),3.5bs (0,78H,4.4m (0.94H),

Deprotection of BOC protected hydantoins was performed via 40% trifluoroacetic acid in DCM and the final compound 5-(1-aminoethyl) 5-alkyl imidazoline-2,4 dione trifluoracetate was precipitated by ether after evaporated to dryness.

R-5-(S-1-aminoethyl)-imidazoline-2,4-dione trifluoroacetate
LC-MS(APCI): $M^+ + H^+ = 144.2$ *(m/z)*

R-5-(1-aminoethyl)-5-S-methyl imidazolidine-2,4-dione trifluoroacetate
LC-MS(APCI): $M^+ + H^+ = 158.2$ *(m/z)*

R-5-(1-aminoethyl)-5-R-methyl imidazolidine-2,4-dione trifluoroacetate

LC-MS(APCI): $M^+ + H^+ = 158.2$ *(m/z)*

R-5-(1-aminoethyl)-5-S-phenylimidazolidine-2,4-dione trifluoroacetate

LC-MS(APCI): $M^+ + H^+ = 220.3$ *(m/z)*

(5R)-5-[(2S)-pyrrolidin-2-yl]imidazolidine-2,4-dione trifluoroacetate

LC-MS(APCI): $M^+ + H^+ = 169.1$ *(m/z)*

(5R)-5-[(2R)-pyrrolidin-2-yl]imidazolidine-2,4-dione

LC-MS(APCI): $M^+ + H^+ = 169.1$ *(m/z)*

(5R)-5-[(2S)-pyrrolidin-2-yl]imidazolidine-2,4-dione

LC-MS(APCI): $M^+ + H^+ = 169.1$ *(m/z)*

(5S)-5-[(2S)-pyrrolidin-2-yl]imidazolidine-2,4-dione

LC-MS(APCI): $M^+ + H^+ = 169.1$ *(m/z)*

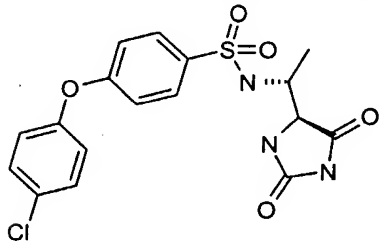
(5S)-5-methyl-5-[(2R)-pyrrolidin-2-yl]imidazolidine-2,4-dione

LC-MS(APCI): $M^+ + H^+ = 183.21$ *(m/z)*

(c) **Preparation of hydantoins of formula I**

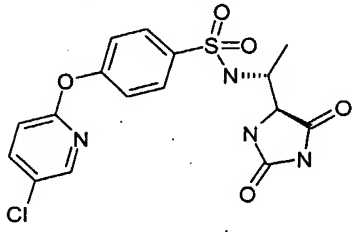
Synthesis was performed in parallel, on 20 well plates, manually operated. Each well was charged by ca 7.5 umol of the corresponding sulfonyl chloride in 0.5 ml of DCM, followed by ca 15-20 umol of the 5-(1-aminoethyl) 5-alkyl imidazoline-2,4-dione trifluoroacetate in 0.5 ml DCM (small amount of DMF added if necessary for complete dissolution) and 10 mg of the diethylaminomethyl polystyrene resin was added. The mixture was shaked overnight, filtered through 200 mg of silica gel (washed with 3-5 ml of ethyl acetate and the purity was monitored by LC-MS. The solutions were evaporated to dryness to afford all expected compounds in sufficient purity.

4-R-(4-chlorophenoxy-N-(1-(2,5dioxoimidazolin-4-S-yl)-ethyl) benzenesulfonamide



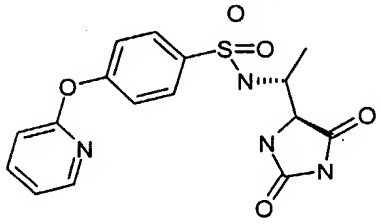
LC-MS(APCI): $M^+ + H^+ = 411.1$ *(m/z)*

4-R-(5-chloropyridin-2-oxy)-N-(1-(2,5-dioxoimidazoline-4-S-yl)-ethyl) benzenesulfonamide



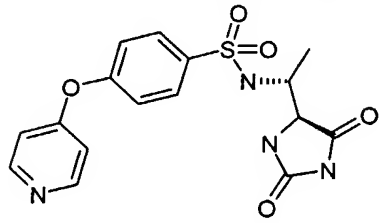
LC-MS(APCI): $M^+ + H^+ = 412.1$ *(m/z)*

R-N-(1-(2,5-dioxo-imidazolidin-S-4-yl) ethyl)-4-(pyridin-2-yloxy)-benzenesulfonamide



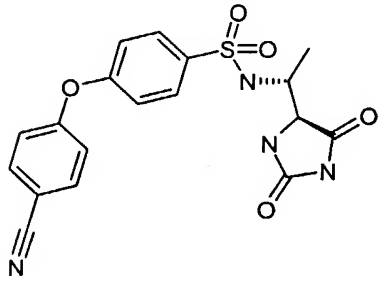
LC-MS(APCI): $M^+ + 2\ H^+ = 378.9$ *(m/z)*

R-N-(1-(2,5-dioxo-imidazolidin-S-4-yl) ethyl)-4-(pyridin-4-yloxy)-benzenesulfonamide



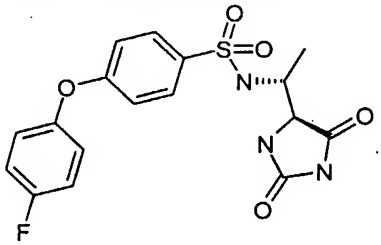
LC-MS(APCI): M^++2 H^+ =378.9 *(m/z)*

4-R-(4-cyanophenoxy-N-(1-(2,5dioxoimidazolin-4-S-yl)-ethyl) benzenesulfonamide



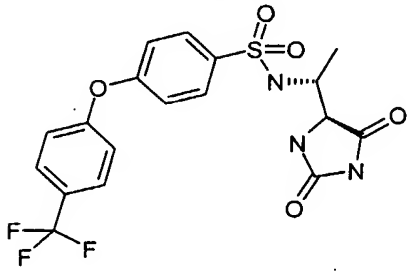
LC-MS(APCI): M^++H^+ =401.5 *(m/z)*

4-R-(4-fluorophenoxy-N-(1-(2,5dioxoimidazolin-4-S-yl)-ethyl) benzenesulfonamide



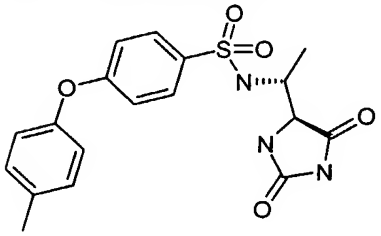
LC-MS(APCI): M^++ H^+ =394.3 *(m/z)*

4-R-(4-trifluoromethylphenoxy-N-(1-(2,5dioxoimidazolin-4-S-yl)-ethyl) benzenesulfonamide



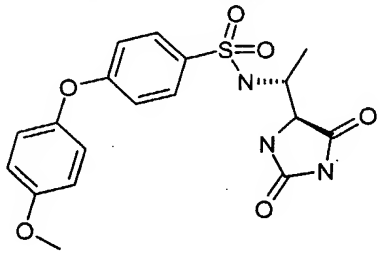
LC-MS(APCI): $M^+ + H^+ = 444.4$ *(m/z)*

4-R-(4-methylphenoxy-N-(1-(2,5dioxoimidazolin-4-S-yl)-ethyl) benzenesulfonamide



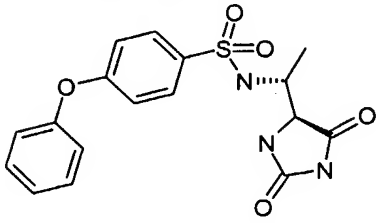
LC-MS(APCI): $M^+ + H^+ = 389.43$ *(m/z)*

4-R-(4-methoxyphenoxy-N-(1-(2,5dioxoimidazolin-4-S-yl)-ethyl) benzenesulfonamide



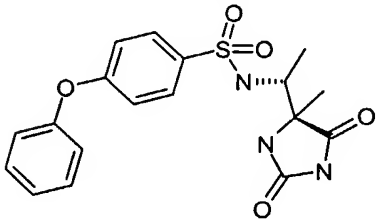
LC-MS(APCI): $M^+ + H^+ = 406.4$ *(m/z)*

4-R-(4-phenoxy-N-(1-(2,5dioxoimidazolin-4-S-yl)-ethyl) benzenesulfonamide



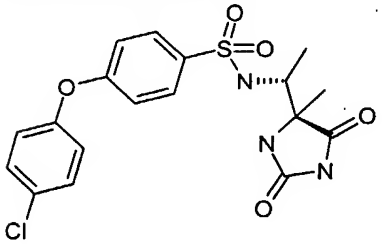
LC-MS(APCI): $M^+ + 2H^+ = 376.2$ *(m/z)*

R-N-(1-(4-methy 2.5-dioxo-imidazolidin-4-S-yl)-ethyl-4-phenoxybenzenesulfonamide



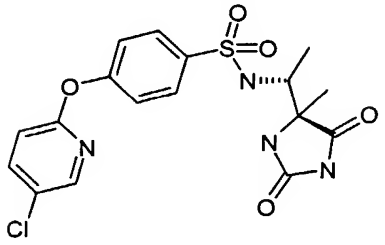
LC-MS(APCI): $M^+ + H^+ = 390.4$ *(m/z)*

4-(4-Chlorohenoxy-N-(1-(4-S-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



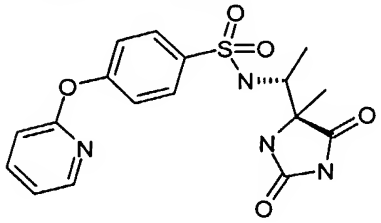
LC-MS(APCI): $M^+ + H^+ = 423.4$ *(m/z)*

4-(5-chloropyridyl-2-oxy)-N-(1-(4-S-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



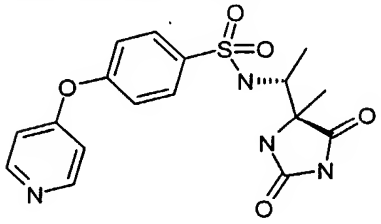
LC-MS(APCI): $M^+ + H^+ = 424.4$ *(m/z)*

N-(1-(4-S-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl)-4-(pyridin-2-yloxy) benzenesulfonamide



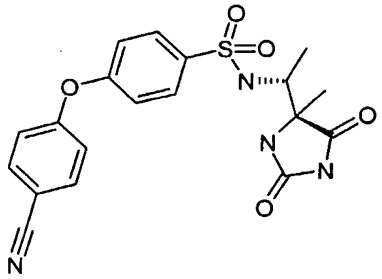
LC-MS(APCI): $M^+ + 2H^+ = 392.4$ *(m/z)*

N-(1-(4-S-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl)-4-(pyridin-2-yloxy) benzenesulfonamide



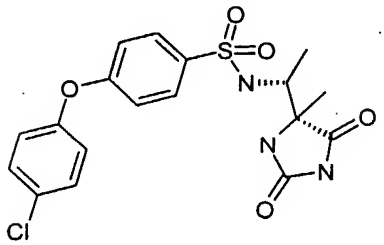
LC-MS(APCI): $M^+ + 2H^+ = 392.4$ *(m/z)*

4-(4-cyanophenoxy-N-(1-(4-S-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



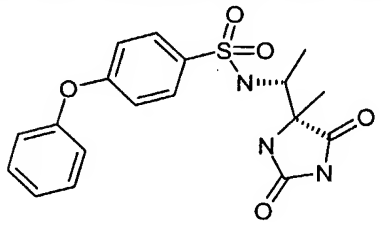
LC-MS(APCI): $M^+ + 2H^+ = 415.4$ *(m/z)*

4-(4-Chlorohenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



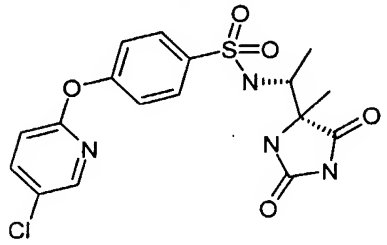
LC-MS(APCI): $M^+ + H^+ = 423.4$ *(m/z)*

R-N-(1-(4-methy 2,5-dioxo-imidazolidin-4-R-yl)-ethyl-4-phenoxybenzenesulfonamide



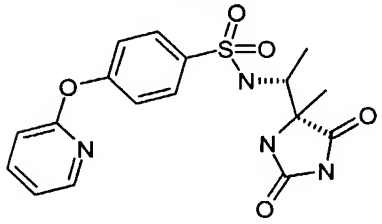
LC-MS(APCI): $M^+ + H^+ = 390.4$ *(m/z)*

4-(5-chloropyridyl-2-oxy)-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



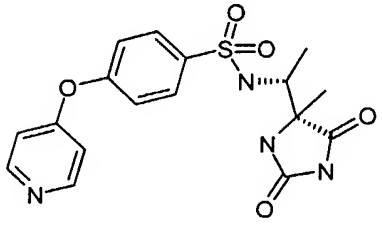
LC-MS(APCI): $M^+ + H^+ = 424.4$ *(m/z)*

N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl)-4-(pyridin-2-yloxy) benzenesulfonamide



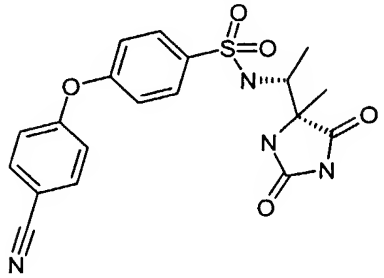
LC-MS(APCI): $M^+ + 2H^+ = 392.4$ *(m/z)*

N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl)-4-(pyridin-2-yloxy) benzenesulfonamide



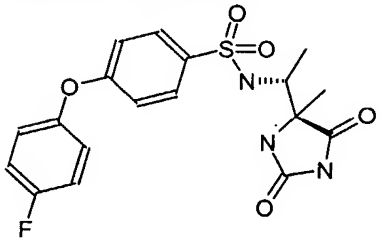
LC-MS(APCI): $M^+ + 2H^+ = 392.4$ *(m/z)*

4-(4-cyanophenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



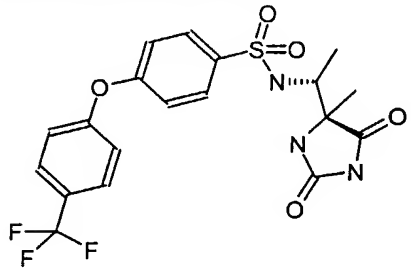
LC-MS(APCI): $M^+ + H^+ = 415.4$ *(m/z)*

4-(4-fluorophenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-S-yl)-ethyl benzenesulfonamide



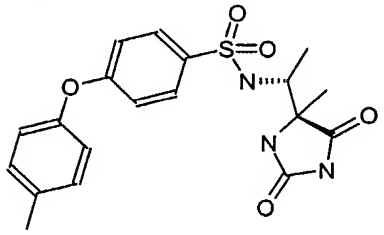
LC-MS(APCI): $M^+ + H^+ = 407.4$ *(m/z)*

4-(4-trifluoromethylphenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-S-yl)-ethyl benzenesulfonamide



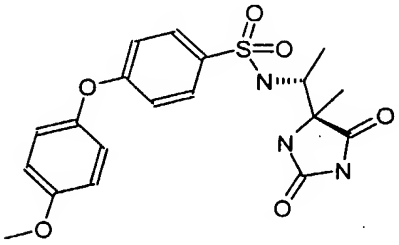
LC-MS(APCI): $M^+ + H^+ = 458.4$ *(m/z)*

4-(4-Methylphenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-S-yl)-ethyl benzenesulfonamide



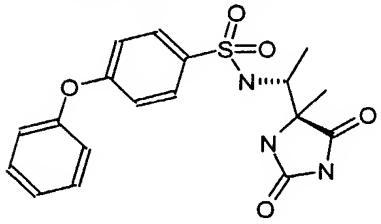
LC-MS(APCI): $M^+ + H^+ = 404.5$ *(m/z)*

4-(4-Methoxyphenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-S-yl)-ethyl benzenesulfonamide



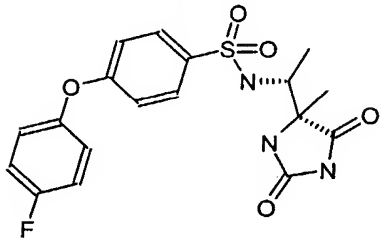
LC-MS(APCI): $M^+ + H^+ = 420.5$ *(m/z)*

4-(4-Phenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-S-yl)-ethyl benzenesulfonamide



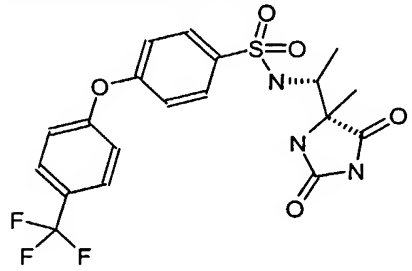
LC-MS(APCI): $M^+ + H^+ = 390.5$ *(m/z)*

4-(4-fluorophenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



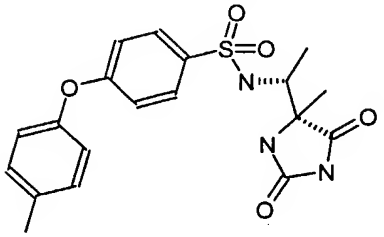
LC-MS(APCI): $M^+ + H^+ = 407.4$ *(m/z)*

4-(4-trifluoromethylphenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



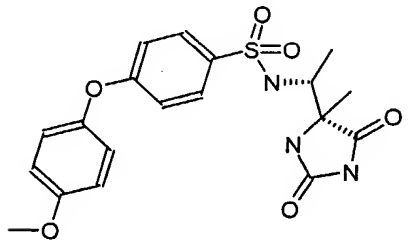
LC-MS(APCI): $M^+ + H^+ = 458.4$ *(m/z)*

4-(4-Methylphenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



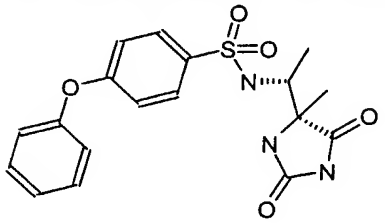
LC-MS(APCI): $M^+ + H^+ = 404.5$ *(m/z)*

4-(4-Methoxyphenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



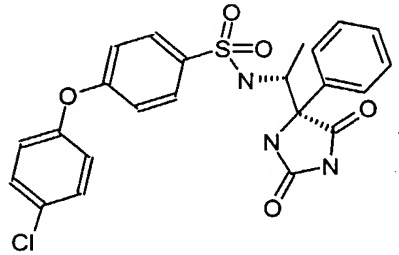
LC-MS(APCI): $M^+ + H^+ = 420.5$ *(m/z)*

4-(4-Phenoxy-N-(1-(4-R-methyl-2,5-dioxoimidazolidin-4-R-yl)-ethyl benzenesulfonamide



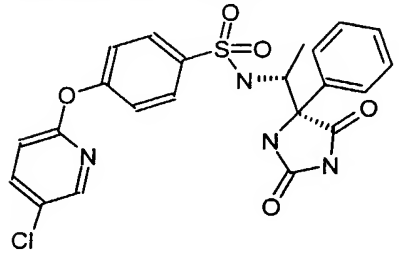
LC-MS(APCI): $M^+ + H^+ = 390.5$ *(m/z)*

4-(4-Chlorophenoxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesuldonamide



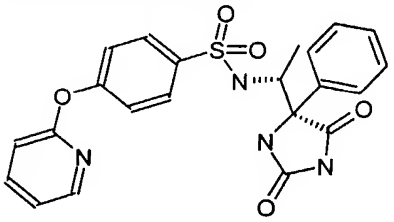
LC-MS(APCI): $M^+ + H^+ = 486.8$ *(m/z)*

4-(5-chloropyridin-2-yloxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesuldonamide



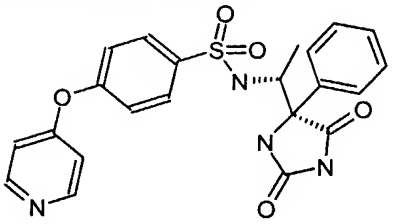
LC-MS(APCI): $M^+ + H^+ = 487.8$ *(m/z)*

N-(1-S-(2,5-dioxo-4-phenylimidazolidin-4-R-yl)-ethyl-4-(pyridin-2-yloxy)-benzenesulfonamide



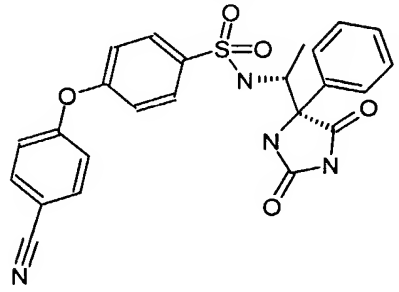
LC-MS(APCI): $M^+ + 2H^+ = 454.6$ *(m/z)*

N-(1-S-(2,5-dioxo-4-phenylimidazolidin-4-R-yl)-ethyl-4-(pyridin-4-yloxy)-benzenesulfonamide



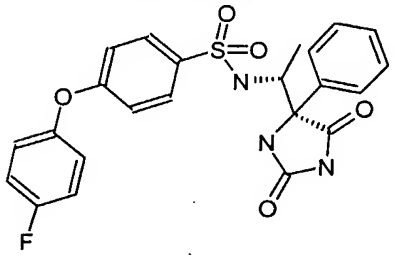
LC-MS(APCI): $M^+ + 2H^+ = 454.6$ *(m/z)*

4-(4-Cyanophenoxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesulfonamide



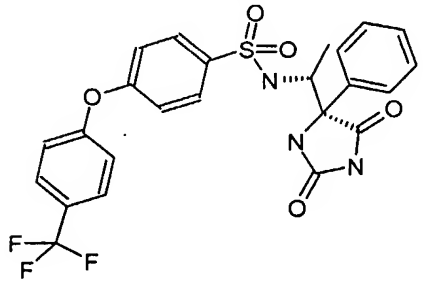
LC-MS(APCI): $M^+ + H^+ = 477.6$ *(m/z)*

4-(4-Fluorophenoxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesulfonamide



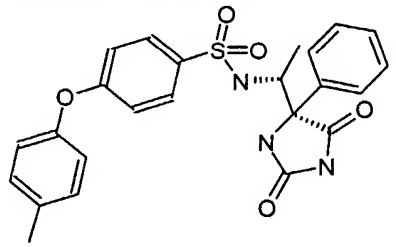
LC-MS(APCI): $M^+ + H^+ = 470.5$ *(m/z)*

4-(4-Trifluoromethylphenoxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesulfonamide



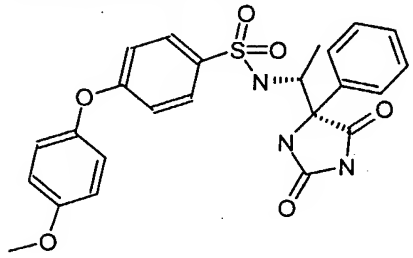
LC-MS(APCI): $M^+ + H^+ = 519.1$ *(m/z)*

4-(4-Methylphenoxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesulfonamide



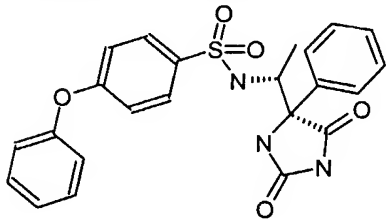
LC-MS(APCI): $M^+ + H^+ = 466.4$ *(m/z)*

4-(4-Methoxyphenoxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesulfonamide



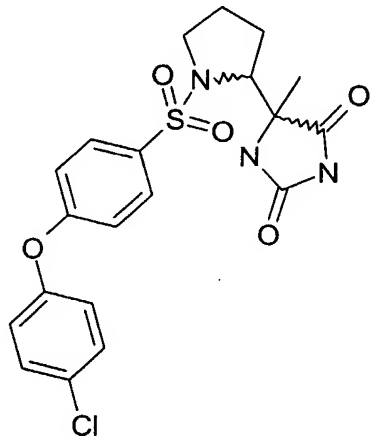
LC-MS(APCI): $M^+ + H^+ = 482.4$ *(m/z)*

4-(4-Phenoxy)-N-(1-((2,5-dioxo-4-S-phenyl-imidazolidin-4-R-yl)-ethyl) benzenesulfonamide



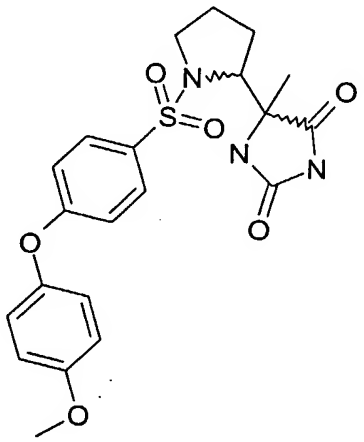
LC-MS(APCI): $M^+ + H^+ = 452.5$ *(m/z)*

5-(1-{[4-(4-chlorophenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)-5-methylimidazolidine-2,4-dione



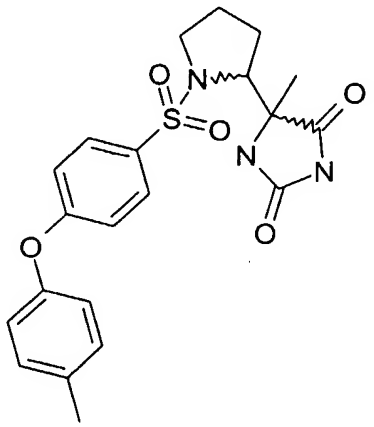
LC-MS(APCI): $M^+ + H^+ = 450.5$ *(m/z)*

5-(1-{[4-(4-methoxyphenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)-5-methylimidazolidine-2,4-dione



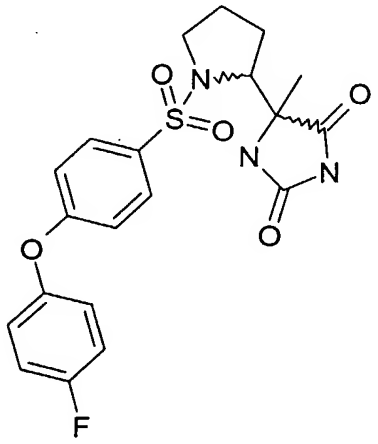
LC-MS(APCI): $M^+ + H^+ = 446.2$ *(m/z)*

5-(1-{[4-(4-methylphenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)-5-methylimidazolidine-2,4-dione



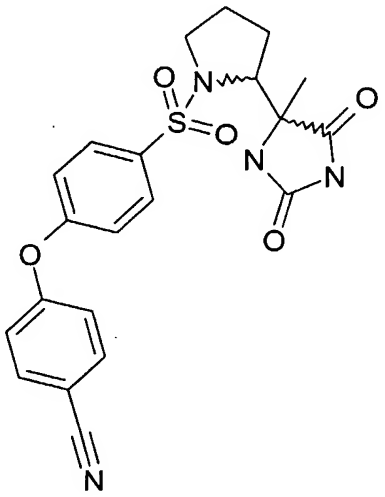
LC-MS(APCI): $M^+ + H^+ = 430.1$ *(m/z)*

5-(1-{[4-(4-fluorophenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)-5-methylimidazolidine-2,4-dione



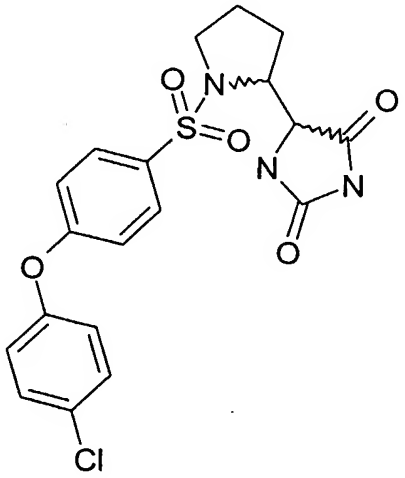
LC-MS(APCI): $M^+ + H^+ = 434.1$ *(m/z)*

(1-{[4-(4-cyanophenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)-5-methylimidazolidine-2,4-dione



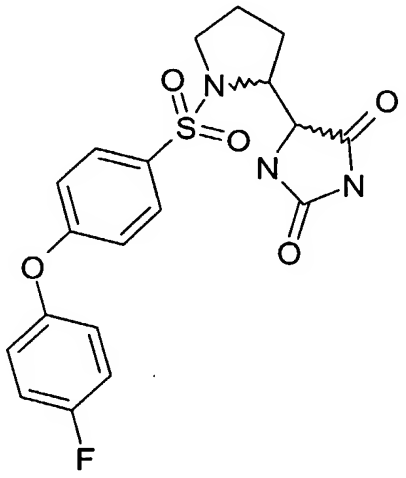
LC-MS(APCI): $M^+ + H^+ = 441.1$ *(m/z)*

5-(1-{[4-(4-chlorophenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)imidazolidine-2,4-dione



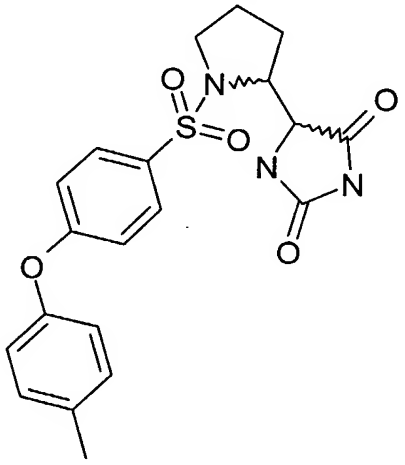
LC-MS(APCI): $M^+ + H^+ = 436.1$ *(m/z)*

5-(1-{[4-(4-fluorophenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)imidazolidine-2,4-dione



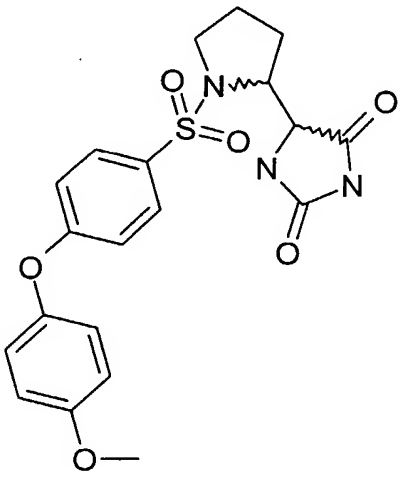
LC-MS(APCI): $M^+ + H^+ = 420.1$ *(m/z)*

5-(1-{[4-(4-methylphenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)imidazolidine-2,4-dione



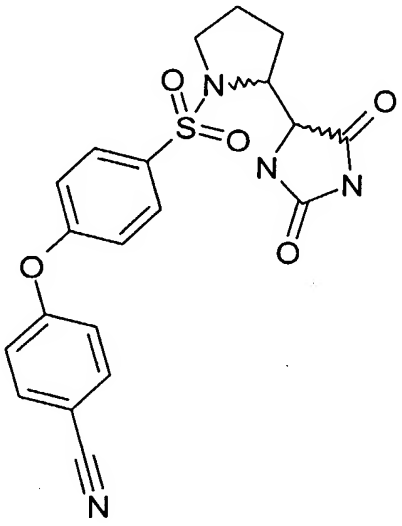
LC-MS(APCI): $M^+ + H^+ = 416.1$ *(m/z)*

5-(1-{[4-(4-methoxyphenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)imidazolidine-2,4-dione



LC-MS(APCI): $M^+ + H^+ = 432.1$ *(m/z)*

5-(1-{[4-(4-cyanophenoxy)phenyl]sulfonyl}pyrrolidin-2-yl)imidazolidine-2,4-dione



LC-MS(APCI): $M^+ + H^+ = 427.1$ *(m/z)*

EXAMPLE 4

[(4*R*)-2,5-dioxoimidazolidinyl]methanesulfonyl chloride, [(4*S*)-2,5-dioxoimidazolidinyl]methanesulfonyl chloride or [(*R*)-2,5-Dioxoimidazolidinyl]-methanesulfonyl chloride was reacted with the appropriate primary or secondary amine to give the compounds listed below. All the amines employed are commercially available.

Sulfonyl chloride (0.060 mmoles), amine (0.060 mmoles), triethylamine (0.0084 mL, 0.060 mmoles) in dry tetrahydrofuran (0.70 mL) were stirred at room temperature over night. Polystyrene methylisocyanate (0.025 g, 0.030 mmoles) was added and the mixture was shaken over night. The white suspension was filtered and the solids were rinsed with tetrahydrofuran (2x1 mL). The filtrates were evaporated, the white solid was suspended in water (5 mL), collected on a filter, washed with water (2x1 mL), sucked free of water and dried in vacuo at 45°C over night to afford the title compounds.

The starting materials were prepared as follows:

5-methyl-5-{[(phenylmethyl)thio]methyl}imidazolidine-2,4-dione

A steel vessel was charged with ethanol and water (315mL/135mL).
31.7g (0.175 mol) of benzylthioacetone, 22.9g (0.351 mol) of potassium cyanide and 84.5g (0.879 mol) of ammonium carbonate was added. The closed reaction vessel was kept in an oil bath (bath temperature 90 °C) under vigorous stirring for 3h.
The reaction vessel was cooled with ice-water (0.5 h), the yellowish slurry was evaporated to dryness and the solid residue partitioned between 400 mL water and 700 mL ethylacetate and separated. The water-phase was extracted with ethylacetate (300 mL). The combined organic phases were washed with saturated brine (150 mL), dried (Na_2SO_4), filtered and evaporated to dryness. If the product did not crystallize, 300 mL of dichloromethane was added to the oil. Evaporation gave the product as a slightly yellowish powder,43.8 g (90%).

LC-MS (APCI) m/z 251.1 (MH+).

^{1}H NMR (DMSO-d_6) δ: 10.74 (1H,s); 8.00 (1H, s); 7.35-7.20 (5H, m); 3.76 (2H, s); 2.72, 2.62 (1H each, ABq, *J*=14.0 Hz); 1.29 (3H, s).

^{13}C NMR (DMSO-d_6) δ: 177.30, 156.38, 138.11, 128.74, 128.24, 126.77, 62.93, 37.96, 36.39, 23.15.

(5*S*)-5-methyl-5-{[(phenylmethyl)thio]methyl}imidazolidine-2,4-dione

The title compound was prepared by chiral separation of the racemic material using a 250mm x 50mm column on a Dynamic Axial Compression Preparative HPLC system. The stationary phase used was CHIRALPAK AD, eluent=Methanol, flow=89mL/min, temp=ambient, UV=220nm, sample conc=150mg/mL, injection volume=20mL.

Retention time for title compound = 6 min.

Analysis of chiral purity was made using a 250mm x 4.6mm CHIRALPAK-AD column from Daicel, flow=0.5mL/min, eluent=Ethanol, UV=220nm, temp=ambient.

Retention time for title compound = 9.27min.

Purity estimated to >99% ee.

LC-MS (APCI) m/z 251.1 (MH+).

$[\alpha]_D$=-30.3° (c=0.01g/mL, MeOH, T=20°C).

^{1}H NMR (DMSO-d_6) δ: 10.74 (1H,s); 8.00 (1H, s); 7.35-7.20 (5H, m); 3.76 (2H, s); 2.72, 2.62 (1H each, ABq, *J*=14.0 Hz); 1.29 (3H, s).

^{13}C NMR (DMSO-d_6) δ: 177.30, 156.28, 138.11, 128.74, 128.24, 126.77, 62.93, 37.96, 36.39, 23.15.

(5*R*)-5-methyl-5-{[(phenylmethyl)thio]methyl}imidazolidine-2,4-dione

The title compound was prepared by chiral separation of the racemic material using a 250mm x 50mm column on a Dynamic Axial Compression Preparative HPLC system. The stationary phase used was CHIRALPAK AD, eluent=Methanol, flow=89mL/min, temp=ambient, UV=220nm, sample conc=150mg/mL, injection volume=20mL.

Retention time for title compound = 10 min.

Analysis of chiral purity was made using a 250mm x 4.6mm CHIRALPAK-AD column from Daicel, flow=0.5mL/min, eluent=Ethanol, UV=220nm, temp=ambient.
Retention time for title compound = 17.81 min.
Chiral purity estimated to >99% ee.
LC-MS (APCI) m/z 251.0 (MH+).
$[\alpha]_D$=+30.3° (c=0.01g/mL, MeOH, T=20°C).
^{1}H NMR (DMSO-d_6) δ: 10.74 (1H,s); 8.00 (1H, s); 7.35-7.20 (5H, m); 3.76 (2H, s); 2.72, 2.62 (1H each, ABq, *J*=14.0 Hz); 1.29 (3H, s).
^{13}C NMR (DMSO-d_6) δ: 177.31, 156.30, 138.11, 128.74, 128.25, 126.77, 62.94, 37.97, 36.40, 23.16.

[(4*S*)-4-methyl-2,5-dioxoimidazolidin-4-yl]methanesulfonyl chloride

(5S)-5-methyl-5-{[(phenylmethyl)thio]methyl}imidazolidine-2,4-dione (42.6g; 0.17mol) was dissolved in a mixture of AcOH (450 mL) and H_2O (50 mL). The mixture was immersed in an ice/water bath, Cl_2 (g) was bubbled through the solution, the flow of gas was adjusted so that the temperature was kept below +15 °C. After 25 min the solution became yellow-green in colour and a sample was withdrawn for LC/MS and HPLC analysis. It showed that starting material was consumed. The yellow clear solution was stirred for 30 min and an opaque solution /slurry was formed.
The solvent was removed on a rotary evaporator using waterbath with temperature held at +37°C. The yellowish solid was suspended in Toluene (400mL) and solvent removed on the same rotary evaporator. This was repeated once more.
The crude product was then suspended in iso-Hexane (400mL) and warmed to +40°C while stirring, the slurry was allowed to cool to room temperature before the insoluble product was removed by filtration, washed with iso-Hexane (6x100mL), and dried under reduced preassure at +50°C over night. This gave the product as a slightly yellow powder.
Obtained 36.9 g (95%) of the title compound.
Purity by HPLC = 99%, NMR supported that purity.
$[\alpha]_D$=-12.4° (c=0.01g/mL, THF, T=20°C).

^{1}H NMR (THF-d_8): δ 9.91 (1H, bs); 7.57 (1H, s); 4.53, 4.44 (1H each, ABq, *J*=14.6Hz); 1.52 (s, 3H, CH_3).

^{13}C NMR (THF-d_8): δ 174.96; 155.86; 70.96; 61.04; 23.66.

[(4*R*)-4-methyl-2,5-dioxoimidazolidin-4-yl]methanesulfonyl chloride

Following the procedure described for [(4S)-4-methyl-2,5-dioxoimidazolidin-4-yl]methanesulfonyl chloride.

Starting from (5R)-5-methyl-5-{[(phenylmethyl)thio]methyl}imidazolidine-2,4-dione (10.0g, 40mmol).

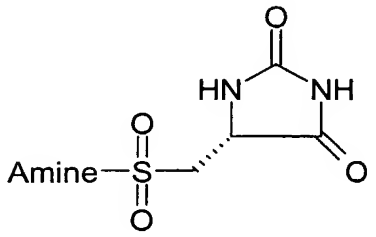
Obtained 8.78g (96% yield) of the title compound.

Purity by NMR > 98%.

$[\alpha]_D$=+12.8° (c=0.01g/mL, THF, T=20°C).

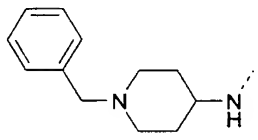
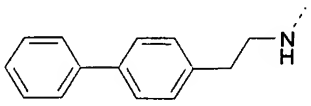
^{1}H NMR (THF-d_8): δ 9.91 (1H, brs); 7.57 (1H, s); 4.53, 4.44 (1H each, ABq, *J*=14.6Hz); 1.52 (s, 3H, CH_3).

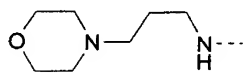
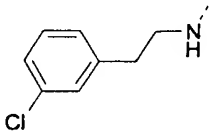
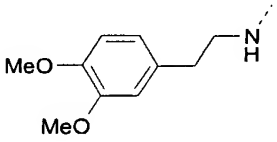
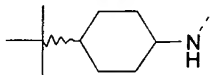
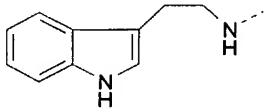
^{13}C NMR (THF-d_8): δ 174.96; 155.84; 70.97; 61.04; 23.66.

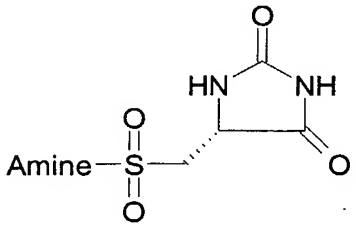


(R)-

The Table below gives the Amine group for each compound of the above structure.

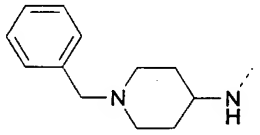
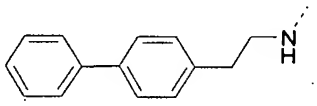
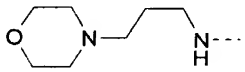
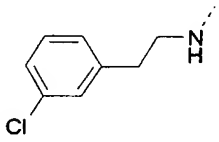
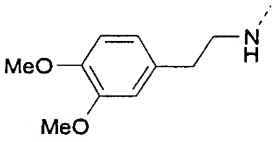
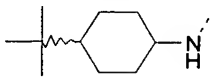
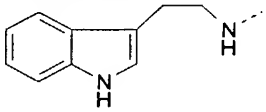
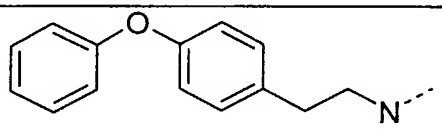
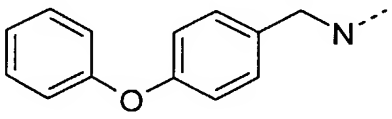
 MW. 366 m/z 367 (M+1)	 MW. 373.43 m/z 374 (M+1)

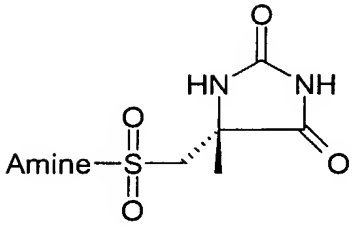
 MW.320 m/z 321 (M+1)	 MW. 331.78 m/z 332 (M+1)
 MW. 357.39 m/z 358 (M+1)	 MW. 331.44 m/z 332 (M+1)
 MW. 336.37 m/z 337 (M+1)	



(S)-

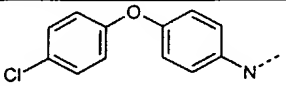
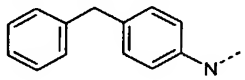
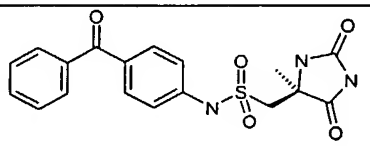
The Table below gives the Amine group for each compound of the above structure.

 MW. 366 m/z 367 (M+1)	 MW. 373.43 m/z 374 (M+1)
 MW.320 m/z 321 (M+1)	 MW. 331.78 m/z 332 (M+1)
 MW. 357.39 m/z 358 (M+1)	 MW. 331.44 m/z 332 (M+1)
 MW. 336.37 m/z 337 (M+1)	 MW. 403.46 m/z 404 (M+1)
 MW. 389.43 m/z 390 (M+1)	



(S)-

The Table below gives the Amine group for each compound of the above structure.

Hydantoin	Analysis[1]
	MW. 375.41 m/z 410 (MH+)
	m/z 374 (MH+) MW. 373.43
	m/z 388 (MH+) MW. 387.42

<u>*N*-[4-(4-Chloro-phenoxy)-phenyl]-*C*-((4*S*)-4-methyl-2,5-dioxo-imidazolidin-4-yl)-methanesulfonamide</u>

LC-MS (APCI) m/z 410 (MH+).

^{1}H NMR (DMSO- d_6): δ 10.75 (1 H, s); 9.89 (1 H, s); 8.04 (1 H, s); 7.45-7.39 (2 H, m); 7.25-7.19 (2 H, m); 7.06-6.97 (4 H, m); 3.54 (1 H from ABq, *J*=14.1 Hz); 1.31 (3 H, s).

<u>*N*-(4-Benzyl-phenyl)-*C*-((4*S*)-4-methyl-2,5-dioxo-imidazolidin-4-yl)-methanesulfonamide</u>

LC-MS (APCI) m/z 374 (MH+).

^{1}H NMR (DMSO- d_6): δ 10.74 (1 H, s); 9.82 (1 H, s); 8.01 (1 H, s); 7.33-7.05 (9 H, m); 3.49, 3.36 (1 H each, ABq, *J*=16.2 Hz); 1.28 (3 H, s).

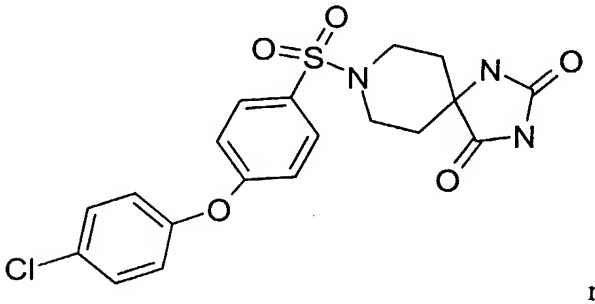
***N*-(4-Benzoyl-phenyl)-*C*-((4*S*)-4-methyl-2,5-dioxo-imidazolidin-4-yl)-methanesulfonamide**

LC-MS (APCI) m/z 388 (MH+).

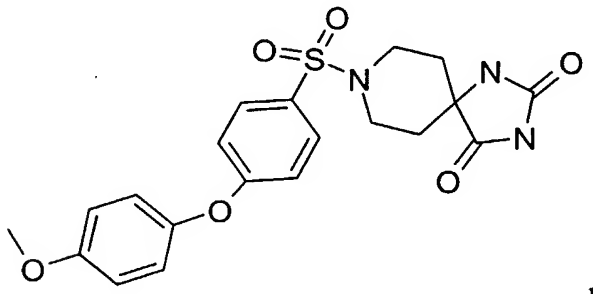
^{1}H NMR (DMSO- d_6): δ 10.81 (1 H, s); 10.58 (1 H, s); 8.08 (1 H, s); 7.76-7.62 (5 H, m); 7.60-7.52 (2 H, m); 7.33-7.27 (2 H, m); 3.68, 3.52 (1 H each, ABq, *J*=14.7 Hz); 1.33 (3 H, s).

EXAMPLE 5

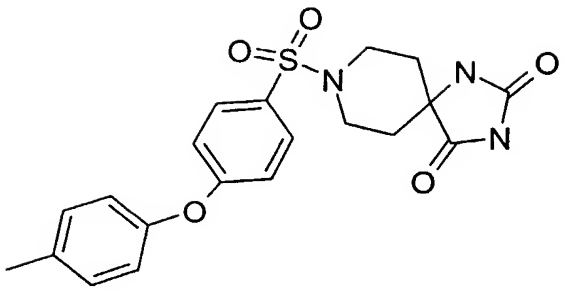
Prepared from commercially available N-Boc-4-piperidone by methods described in Example 3.



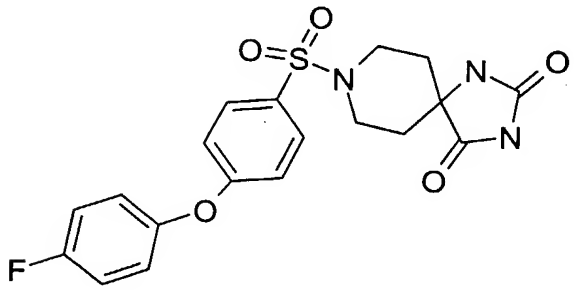
m/z 437 (MH+) MW. 435.89



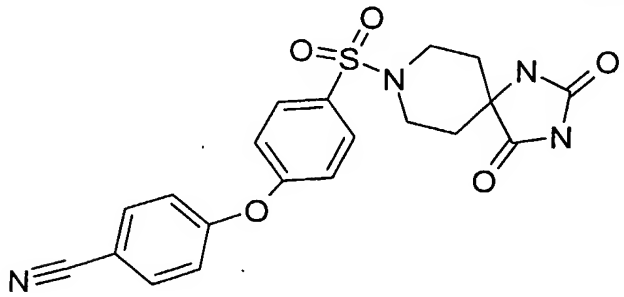
m/z 432 (MH+) MW. 431.47



m/z 416 (MH+) MW. 415.47



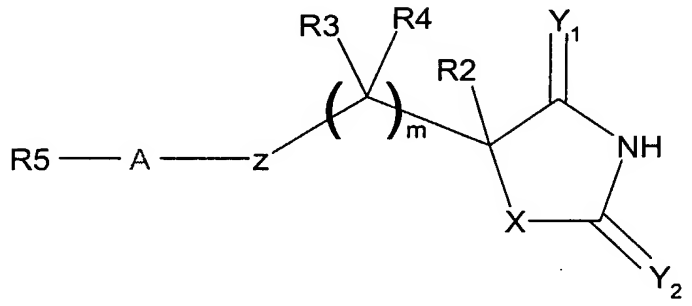
m/z 420 (MH+) MW. 419.43



m/z 427 (MH+) MW. 426.45

CLAIMS:
What we claim is:

1. A compound of the formula I or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof



I

wherein

X is selected from NR1, O, S;

Y1 and Y2 are independently selected from O, S;

Z is selected from $SO_2N(R6)$, $N(R7)SO_2$, $N(R7)SO_2N(R6)$;

m is 1 or 2;

A is selected from a direct bond, (C1-6)alkyl, (C1-6)haloalkyl, or (C1-6)heteroalkyl containing a hetero group selected from N, O, S, SO, SO2 or containing two hetero groups selected from N, O, S, SO, SO2 and separated by at least two carbon atoms;

R1 is selected from H, (C1-3)alkyl, haloalkyl;

Each R2 and R3 is independently selected from H, halogen, alkyl, heteroalkyl, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, alkylaryl, alkyl-heteroaryl, heteroalkyl-aryl, heteroalkyl-heteroaryl, aryl-alkyl, aryl-heteroalkyl, heteroaryl-alkyl, heteroaryl-heteroalkyl, aryl-aryl, aryl-heteroaryl, heteroaryl-aryl, heteroaryl-heteroaryl, cycloalkyl-alkyl, heterocycloalkyl-alkyl;

Each R4 is independently selected from H, halogen, (C1-3)alkyl or haloalkyl;

R6 is selected from H, alkyl, heteroalkyl, heterocycloalkyl, aryl, heteroaryl, alkylaryl, alkyl-heteroaryl, heteroalkyl-aryl, heteroalkyl-heteroaryl, arylalkyl, aryl-heteroalkyl,

heteroaryl-alkyl, heteroaryl-heteroalkyl, aryl-aryl, aryl-heteroaryl, heteroaryl-aryl, heteroaryl-heteroaryl;

Each of the R2, R3 and R6 radicals may be independently optionally substituted with one or more groups selected from alkyl, heteroalkyl, aryl, heteroaryl, halo, haloalkyl, hydroxy, alkoxy, haloalkoxy, thiol, alkylthiol, arylthiol, alkylsulfon, haloalkylsulfon, arylsulfon, aminosulfon, N-alkylaminosulfon, N,N-dialkylaminosulfon, arylaminosulfon, amino, N-alkylamino, N,N-dialkylamino, amido, N-alkylamido, N,N-dialkylamido, cyano, sulfonamino, alkylsulfonamino, arylsulfonamino, amidino, N-aminosulfon-amidino, guanidino, N-cyano-guanidino, thioguanidino, 2-nitro-ethene-1,1-diamin, carboxy, alkyl-carboxy, nitro;

Optionally R2 and R3 may join to form a ring comprising up to 7 ring atoms, or R2 and R4 may join to form a ring comprising up to 7 ring atoms, or R2 and R6 may join to form a ring comprising up to 7 ring atoms, or R3 and R4 may join to form a ring comprising up to 7 ring atoms, or R3 and R6 may join to form a ring comprising up to 7 ring atoms, or R4 and R6 may join to form a ring comprising up to 7 ring atoms;

R5 is a monocyclic, bicyclic or tricyclic group comprising one, two or three ring structures each of up to 7 ring atoms independently selected from cycloalkyl, aryl, heterocycloalkyl or heteroaryl, with each ring structure being independently optionally substituted by one or more substituents independently selected from halogen, hydroxy, alkyl, alkoxy, haloalkoxy, amino, N-alkylamino, N,N-dialkylamino, alkylsulfonamino, alkylcarboxyamino, cyano, nitro, thiol, alkylthiol, alkylsulfonyl, haloalkylsulfonyl, alkylaminosulfonyl, carboxylate, alkylcarboxylate, aminocarboxy, N-alkylamino-carboxy, N,N-dialkylamino-carboxy, wherein any alkyl radical within any substituent may itself be optionally substituted with one or more groups selected from halogen, hydroxy, alkoxy, haloalkoxy, amino, N-alkylamino, N,N-dialkylamino, N-alkylsulfonamino, N-alkylcarboxyamino, cyano, nitro, thiol, alkylthiol, alkylsulfonyl, N-alkylaminosulfonyl, carboxylate, alkylcarboxy, aminocarboxy, N-alkylaminocaboxy, N,N-dialkylaminocarboxy;

when R5 is a bicyclic or tricyclic group, each ring structure is joined to the next ring structure by a direct bond, by -O-, by (C1-6)alkyl, by (C1-6)haloalkyl, by (C1-6)heteroalkyl, by (C1-6)alkenyl, by (C1-6)alkynyl, by sulfone, or is fused to the next ring structure;

R7 is selected from (C1-6) alkyl, (C3-7)cycloalkyl, (C2-6)heteroalkyl, (C2-6)cycloheteroalkyl;

Provided that:

when X is NR1, R1 is H, Y1 is O, Y2 is O, Z is $SO_2N(R6)$, R6 is H, R2 is H, m is 1, R3 is H, R4 is H, and A is a direct bond, then R5 is not phenyl, p-nitro-phenyl, p-ethoxyphenyl or m-methylphenyl;

when X is S or NR1 and R1 is H, Y1 is O, Y2 is O, Z is $SO_2N(R6)$, R6 is alkyl, R2 is H, m is 1, one of R3 and R4 is H and the other is alkyl, R3 and R6 or R4 and R6 join to form a 5-membered ring, and A is a direct bond, then R5 is not phenyl.

2. A compound of the formula I as claimed in claim 1 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein X is NR1, R1 is H or (C1-3) alkyl or C1-3) haloalkyl, at least one of Y1 and Y2 is O, Z is $SO_2N(R6)$, m is 1.

3. A compound as claimed in either claim 1 or claim 2 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein R2 is H, alkyl, hydroxyalkyl, aminoalkyl, cycloalkyl-alkyl, alkyl-cycloalkyl, arylalkyl, alkylaryl, heteroalkyl, heterocycloalkyl-alkyl, alkyl-heterocycloalkyl, heteroaryl-alkyl, heteroalkyl-aryl.

4. A compound as claimed in any of the preceding claims or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein each of R3 and R4 is independently selected from H, methyl.

5. A compound of the formula I as claimed in any of the preceding claims or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein R3 and R4 form a 5- or 6-membered ring, or R3 and R6 form a 5- or 6-membered ring, or R4 and R6 form a 5- or 6-membered ring, or R2 and R3 form a 5-membered ring, or R2 and R6 form a 5-membered ring.

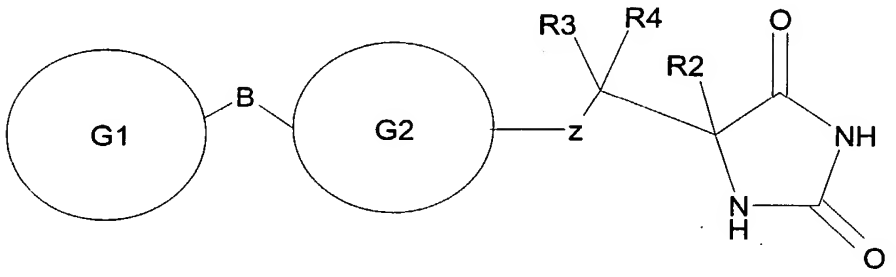
6. A compound of the formula I as claimed in any of the preceding claims or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein R5 comprises one, two or three optionally substituted aryl or heteroaryl 5- or 6-membered rings.

7. A compound of the formula I as claimed in any of the preceding claims or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures.

8. A compound of the formula I as claimed in claim 1 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein Y1 is O, Y2 is O, X is NR1, R1 is H, R2 is H, m is 1, R3 is H, R4 is H, Z is $SO_2N(R6)$, R6 is H, (C1-4)alkyl, methylbenzyl, or methylpyridyl, A is a direct bond, and R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures.

9. A compound of the formula I as claimed in claim 1 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein Y1 is O, Y2 is O, X is NR1, R1 is H, R2 is H, methyl, or benzyl, m is 1, R3 is H or methyl, R4 is H, Z is $SO_2N(R6)$, R6 is H, A is a direct bond, and R5 is a bicyclic or tricyclic group comprising two or three optionally substituted ring structures.

10. A compound of the formula II or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof



II

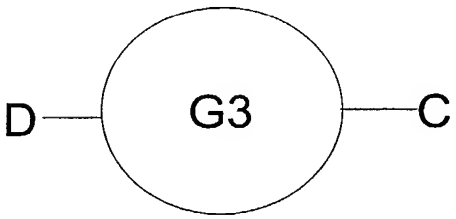
wherein

each of G1 and G2 is a monocyclic ring structure comprising each of up to 7 ring atoms independently selected from cycloalkyl, aryl, heterocycloalkyl or heteroaryl, with each ring structure being independently optionally substituted by one or two substituents independently selected from halogen, hydroxy, haloalkoxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkyl, alkoxy, alkyl sulfone, haloalkyl sulfone, alkylcarbamate, alkylamide, wherein any alkyl radical within any substituent may itself be optionally substituted with one or more groups selected from halogen, hydroxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkoxy, haloalkoxy;

Z is $SO_2N(R6)$;

B is selected from a direct bond, O, (C1-6)alkyl, (C1-6)heteroalkyl;

R2 is selected from H, (C1-6)alkyl, haloalkyl, hydroxyalkyl, alkoxyalkyl, aminoalkyl, (N-alkylamino)alkyl, (N,N-dialkylamino)alkyl, amidoalkyl, thioalkyl, or R2 is a group of formula III



Formula III

C and D are independently selected from a direct bond, H, (C1-C6)alkyl, (C1-C6)haloalkyl, or (C1-C6)heteroalkyl containing one or two hetero atoms selected from N, O or S such that when two hetero atoms are present they are separated by at least two carbon atoms;

G3 is a monocyclic ring structure comprising up to 7 ring atoms independently selected from cycloalkyl, aryl, heterocycloalkyl or heteroaryl, optionally substituted by one or two substituents independently selected from halogen, hydroxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkyl, alkoxy, alkyl sulfone, haloalkyl sulfone, or alkyl substituted with one or more groups selected from halogen, hydroxy, amino, N-alkylamino, N,N-dialkylamino, cyano, nitro, alkoxy, haloalkoxy;

Optionally R2 is substituted with halo, haloalkyl, hydroxy, alkoxy, haloalkoxy, amino, aminoalkyl, N-alkylamino, N,N-dialkylamino, (N-alkylamino)alkyl, (N,N-dialkylamino)alkyl, alkylsulfone, aminosulfone, N-alkylamino-sulfone, N,N-dialkylamino-sulfone, amido, N-alkylamido, N,N-dialkylamido, cyano, sulfonamino, alkyl-sulfonamino, amidino, N-aminosulfone-amidino, guanidino, N-cyano-guanidino, thioguanidino, 2-nitroguanidino, 2-nitro-ethene-1,1-diamino, caboxy, alkylcarboxy;

R3 and R4 are independentyl selected from H or (C1-3)alkyl;

R6 is selected from H, (C1-3)alkylamino, or R6 is (C1-3)alkyl optionally substituted by aryl, heteroaryl, heterocycloalkyl;

Optionally R2 and R3 may join to form a ring comprising up to 7 ring atoms, or R2 and R4 may join to form a ring comprising up to 7 ring atoms, or R2 and R6 may join to form a ring comprising up to 7 ring atoms, or R3 and R4 may join to form a ring comprising up to 7 ring atoms, or R3 and R6 may join to form a ring comprising up to 7 ring atoms, or R4 and R6 may join to form a ring comprising up to 7 ring atoms.

11. A compound of the formula II as claimed in claim 10 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein Z is $SO_2N(R6)$ and the S atom of group Z is attached to the G2 ring.

12. A compound of the formula II as claimed in either claim 10 or claim 11 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein B is a direct bond or O.

13. A compound of the formula II as claimed in any of claims 10 to 12 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein R2 is not optionally substituted, or R2 is selected from H, (C1-6)alkyl, aryl-(C1-6)alkyl or heteroaryl-(C1-6)alkyl optionally substituted with halo, haloalkyl, hydroxy, alkoxy, haloalkoxy, amino, aminoalkyl, N-alkylamino, N,N-dialkylamino, (N-alkylamino)alkyl, (N,N-dialkylamino)alkyl, alkylsulfone, aminosulfone, N-alkylamino-sulfone, N,N-dialkylamino-sulfone, amido, N-alkylamido, N,N-dialkylamido, cyano, sulfonamino, alkyl-sulfonamino, amidino, N-aminosulfone-amidino, guanidino, N-cyano-guanidino, thioguanidino, 2-nitroguanidino, 2-nitro-ethene-1,1-diamino, caboxy, alkylcarboxy.

14. A compound of the formula II as claimed in any of claims 10 to 13 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein each of R3 and R4 is H.

15. A compound of the formula II as claimed in any of claims 10 to 14 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein R6 is H, benzyl or methylenepyridine.

16. A compound of the formula II as claimed in any of claims 10 to 15 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein G1 and G2 are each selected from an aryl or a heteroaryl.

17. A compound of the formula II as claimed in any of claims 10 to 16 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof, wherein R3 and R4 form a 5- or 6-membered ring, or R3 and R6 form a 5- or 6-membered ring, or R4 and R6 form a 5- or 6-membered ring, or R2 and R3 form a 5-membered ring, or R2 and R6 form a 5-membered ring.

18. A pharmaceutical composition which comprises a compound of the formula I as claimed in claim 1 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof and a pharmaceutically acceptable carrier.

19. A pharmaceutical composition which comprises a compound of the formula II as claimed in claim 10 or a pharmaceutically acceptable salt or an in vivo hydrolysable ester thereof and a pharmaceutically acceptable carrier.

20. A method of treating a metalloproteinase mediated disease or condition which comprises administering to a warm-blooded animal a therapeutically effective amount of a compound of the formula I or formula II or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof.

21. Use of a compound of the formula I or formula II or a pharmaceutically acceptable salt or in vivo hydrolysable precursor thereof in the preparation of a medicament for use in the treatment of a disease or condition mediated by one or more metalloproteinase enzymes.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00478

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C07D 233/78, C07D 401/12, C07D 403/12, C07D 403/14, A61K 31/4166, A61K 31/4439, A61K 31/454, A61P 35/00, A61P 11/00, A61P 19/00, A61P 35/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C07D, A61K, A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, CHEM.ABS.DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Chemical Abstracts, Volume 65, 1966, ABSTRACT No. 13684 h, M. Lora-Tamayo et al: "Potential anti-cancer agents. I. Glutamine sulfonate analogs", Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser.B. 62(2), 173-86	1-4,6,18
X	STN International, File CAPLUS, CAPLUS accession number 1968:506154, Document number 69:106154, Lora-Tamayo M. et al: "Potential anticancer agents. VI. Sulfonic analogs of aspartic acid", An.Quim. (1968), 64(6), 591-606	1-4,6,18
A	WO 9906361 A2 (ABBOTT LABORATORIES CHAD), 11 February 1999 (11.02.99)	1-21

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 July 2002	17 -07- 2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer EVA JOHANSSON/BS Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/00478

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9924399 A1 (DARWIN DISCOVERY LIMITED), 20 May 1999 (20.05.99) ---	1-21
A	WO 0105756 A1 (PHARMACIA & UPHOHN SPA), 25 January 2001 (25.01.01) --- --------	1-21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE02/00478

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 20
because they relate to subject matter not required to be searched by this Authority, namely:

see next sheet*

2. ☒ Claims Nos.: 1-7
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

see next sheet**

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

*
Claim 20 relates to a method of treatment of the human or animal body by surgery or by therapy/a diagnostic method practised on the human or animal body/Rule 39.1(iv). Nevertheless, a search has been executed for this claim. The search has been based on the alleged effects of the compounds/compositions.

**
Present claims 1-7 relate to an extremely large number of possible compounds. Support within the meaning of Article 6 PCT and or disclosure within the meaning of Article 5 PCT is to be found, however, for only a very small proportion of the compounds claimed. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible.

Consequently, the search has been carried out for those parts of the claims which appear to be supported and disclosed, namely those parts related to the compounds according to the examples in the description.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SE 02/00478

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9906361 A2	11/02/99	AU 8513998 A	22/02/99
		BG 103995 A	31/07/00
		BR 9810760 A	27/11/01
		CN 1261876 T	02/08/00
		EP 1001930 A	24/05/00
		HU 0002037 A	28/05/01
		JP 2001523272 T	20/11/01
		NO 996579 A	24/01/00
		NZ 501166 A	21/12/01
		PL 337854 A	11/09/00
		SK 170599 A	16/05/00
		TR 9903287 T	00/00/00
		ZA 9806828 A	29/01/99
WO 9924399 A1	20/05/99	AU 1046999 A	31/05/99
		BR 9814147 A	03/10/00
		CA 2308359 A	20/05/99
		CN 1283183 T	07/02/01
		EP 1030836 A	30/08/00
		GB 9723906 D	00/00/00
		JP 2001522832 T	20/11/01
		NO 20002440 A	11/05/00
		PL 340551 A	12/02/01
		US 6187924 B	13/02/01
		ZA 9810360 A	12/11/99
		GB 9802618 D	00/00/00
		GB 9813933 D	00/00/00
WO 0105756 A1	25/01/01	AU 6689900 A	05/02/01
		EP 1200398 A	02/05/02
		GB 9916562 D	00/00/00